This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at http://books.google.com/

Dette er en digital utgave av en bok som i generasjoner har vært oppbevart i bibliotekshyller før den omhyggelig ble skannet av Google som del av et prosjekt for å gjøre verdens bøker tilgjengelige på nettet.

Den har levd så lenge at opphavretten er utløpt, og boken kan legges ut på offentlig domene. En offentlig domene-bok er en bok som aldri har vært underlagt opphavsrett eller hvis juridiske opphavrettigheter har utløpt. Det kan variere fra land til land om en bok finnes på det offentlige domenet. Offentlig domene-bøker er vår port til fortiden, med et vell av historie, kultur og kunnskap som ofte er vanskelig å finne fram til.

Merker, notater og andre anmerkninger i margen som finnes i det originale eksemplaret, vises også i denne filen - en påminnelse om bokens lange ferd fra utgiver til bibiliotek, og til den ender hos deg.

Retningslinjer for bruk

Google er stolt over å kunne digitalisere offentlig domene-materiale sammen med biblioteker, og gjøre det bredt tilgjengelig. Offentlig domene-bøker tilhører offentligheten, og vi er simpelthen deres "oppsynsmenn". Dette arbeidet er imidlertid kostbart, så for å kunne opprettholde denne tjenesten, har vi tatt noen forholdsregler for å hindre misbruk av kommersielle aktører, inkludert innføring av tekniske restriksjoner på automatiske søk.

Vi ber deg også om følgende:

- Bruk bare filene til ikke-kommersielle formål
  Google Book Search er designet for bruk av enkeltpersoner, og vi ber deg om å bruke disse filene til personlige, ikke-kommersielle formål.
- Ikke bruk automatiske søk
  Ikke send automatiske søk av noe slag til Googles system. Ta kontakt med oss hvis du driver forskning innen maskinoversettelse, optisk tegngjenkjenning eller andre områder der tilgang til store mengder tekst kan være nyttig. Vi er positive til bruk av offentlig domene-materiale til slike formål, og kan være til hjelp.
- Behold henvisning
  Google-"vannmerket" som du finner i hver fil, er viktig for å informere brukere om dette prosjektet og hjelpe dem med å finne også annet materiale via Google Book Search. Vennligst ikke fjern.
- Hold deg innenfor loven
  Uansett hvordan du bruker materialet, husk at du er ansvarlig for at du opptrer innenfor loven. Du kan ikke trekke den slutningen at vår vurdering av en bok som tilhørende det offentlige domene for brukere i USA, impliserer at boken også er offentlig tilgjengelig for brukere i andre land. Det varierer fra land til land om boken fremdeles er underlagt opphavrett, og vi kan ikke gi veiledning knyttet til om en bestemt anvendelse av en bestemt bok, er tillatt. Trekk derfor ikke den slutningen at en bok som dukker opp på Google Book Search kan brukes på hvilken som helst måte, hvor som helst i verden. Erstatningsansvaret ved brudd på opphavsrettigheter kan bli ganske stort.

Om Google Book Search

Googles mål er å organisere informasjonen i verden og gjøre den universelt tilgjengelig og utnyttbar. Google Book Search hjelper leserne med å oppdage verdens bøker samtidig som vi hjelper forfattere og utgivere med å nå frem til nytt publikum. Du kan søke gjennom hele teksten i denne boken på http://books.google.com/

BRANNER
GEOLOGICAL LIBRARY

STANFORD UNIVERSITY LIBRARIES

Gift of

Robert H. Palmer Estate

DUPLICA

DEN NORSKE NORDHAVS-EXPEDITION 1876—1878.

CHEMI.

I. OM LUFTEN I SØVANDET.
II. OM KULSYREN I SØVANDET.
III. OM SALTHOLDIGHEDEN AF VANDET I DET NORSKE NORDHAV.

AF

HERCULES TORNØE.

BODL. LIB. CANCELLED
BODL. LIBR. FOREIGN PROGRESS

MED 3 TRÆSNIT OG 3 KARTER.

CHRISTIANIA.
GRØNDAHL & SØNS BOGTRYKKERI.
1880.

CIRCULAR

from the *Editorial Committee* of

The Norwegian North-Atlantic Expedition.

The "General Report of the Norwegian North-Atlantic Expedition" is published in parts, each Memoir being distributed immediately on its leaving the press.

The General Report will comprise the following Memoirs: —

Capt. Wille, R. N. (Narrative of the Expedition — Description of the Apparatus, how constructed and used — Magnetical Observations).

Professor H. Mohn (Meteorology — Deep-sea Temperatures — Motion of the Sea — Astronomical, Geographical, Geological Observations).

Mr. H. Tornøe (Amount of Air in Sea-Water — Amount of Carbonic Acid in Sea-Water — Amount of Salt in Sea-Water).

Mr. L. Schmelck (The Salts in Sea-Water — Investigation of Bottom-Samples).

Professor G. O. Sars (*Crustacea — Pycnogonida — Tunicata — Bryozoa — Hydrozoa — Spongozoa — Rhizopoda — Protophyta*).

Drs. Danielssen & Koren (*Holothurida — Echinida — Asterida — Crinoida — Gephyrea — Anthozoa*).

Mr. H. Friele (*Mollusca — Brachiopoda*).

Dr. G. A. Hansen (*Annulata*).

Mr. R. Collett (Fishes).

The publication of the Report, for which a grant of money has been obtained from the Norwegian Storthing, is conducted in conformity with the directions of His Norwegian Majesty's Government, on whose behalf the Editorial Committee have the honour of presenting Bodleyan Library in Oxford .... with the accompanying Part, the title of which will be found overleaf. The Committee make free to request, that on the publication of scientific works by your Institute, you will kindly remember the scientific institutions and the *savants* of this country with which and with whom you may have been brought into connexion. Of the more important public libraries in Norway, we have been

instructed to name the following: — The library of the University of Christiania; the library of the Meteorological Institute, Christiania; the library of the Bergen Museum; and the library of the Videnskabernes Selskab, Throndhjem.

On the next page is a form of receipt, which you will please fill out, and return, *postage paid*. Compliance with this request constitutes the condition on which to insure the forwarding of the parts subsequently published.

Dr. H. MOHN. Dr. G. O. SARS. Dr. D. C. DANIELSSEN.
Chairman of the Committee.

DEN NORSKE NORDHAVS-EXPEDITION
1876—1878.

General reports

551.461
N863
f
v.1:3-4

CHEMI.

I. OM LUFTEN I SØVANDET.
II. OM KULSYREN I SØVANDET.
III. OM SALTHOLDIGHEDEN AF VANDET
I DET NORSKE NORDHAV.

AF

HERCULES TORNØE.

MED 3 TRÆSNIT OG 3 KARTER.

BODL. LIB.
CANCELLED

CHRISTIANIA.
GRØNDAHL & SØNS BOGTRYKKERI.
1880.

W1

THE NORWEGIAN NORTH-ATLANTIC EXPEDITION

1876—1878.

CHEMISTRY.

I. ON THE AIR IN SEA-WATER.
II. ON THE CARBONIC ACID IN SEA-WATER.
III. ON THE AMOUNT OF SALT IN THE WATER OF THE NORWEGIAN SEA.

BY

HERCULES TORNØE.

WITH 3 WOODCUTS AND 3 MAPS.

BODL. LIB. CANCELLED

BIBLIOTHECA BODL. BODL. LIB. CANCELLED

CHRISTIANIA.
PRINTED BY GRØNDAHL & SØN.
1880.

I. Om Luften i Søvandet.

Allerede i lange Aarrækker har der fra Tid til anden af forskjellige Chemikere været foretaget Experimenter i den Hensigt at studere Forholdene ved den atmosphæriske Lufts Absorbtion af de Vædsker, hvormed den i Naturen kommer i Berøring, men det er dog først i de seneste Aar, at dette Spørgsmaal har været gjort til Gjenstand for mere omfattende Undersøgelser, hvad angaar Søvandet i de aabne Have. Rigtignok foreligger der ogsaa fra ældre Tider enkelte Opgaver over Sammensætning og Mængden af den i Søvandet opløste Luft, men disse ere for det Meste bundne til nogle ganske faa Puncter af Kysterne, og der, hvor Forsøgene ogsaa omfatte Vandprøver fra det aabne Hav, er der ofte saameget at indvende mod Materialets Indsamling og Opbevaring, at man, selv om Intet maatte være at udsætte paa Methoderne til dets Undersøgelse, ikke kunde sætte disse i Klasse med de med vore Tiders fuldkomnere Hjælpemidler udførte Observationer.

Naar saaledes vort Kjendskab til Fordelingen af Luften i Verdenshavene specielt for de store Dybs Vedkommende lige til de seneste Aar maa siges at have været meget mangelfuldt, da maa Grunden hertil søges i de mange Vanskeligheder, som man allevegne møder, naar man vil undersøge disse Spørgsmaal. Hvor det gjælder at bestemme Sammensætningen af den atmosphæriske Luft, giver Luftens Letbevægelighed Ret til af Undersøgelser udførte paa faa Puncter at slutte til den hele Atmosphære, hvad der imidlertid ikke er Anledning til for Søvandets Vedkommende. Der fordrer Havenes langt ringere Bevægelighed et større Antal Observationer, idet der her maa stilles meget strengere Fordringer til den geografiske Udbredning. Enten maatte altsaa Vandprøver hjemføres fra fjerne Farvande, saaledes at de ved en længere Tids Henstand udsatte for allehaande fremmed Indvirkning kunde blive aldeles ubrugbare, eller Analytikeren maatte, udsat for alle de Ulemper, som et Skibs Bevægelser medfører for videnskabelige Undersøgelser, forsøge bedst muligt at udføre sine Observationer ombord. Men selv naar der hos mange Chemikere fra ældre Tider kan have været Interesse for ved Undersøgel-

I. On the Air in Sea-Water.

Experiments have long since been instituted, from time to time, by divers chemists, with the object of investigating the absorption of atmospheric air by the fluids with which in the course of nature it comes in contact; but not till of late years has this phenomenon been made the subject of exhaustive treatment in its relation to ocean-water. True, there do exist comparatively early statements respecting the amount and composition of the air present in seawater, but the great majority of such are confined to a very few coastal localities; and when, as was sometimes the case, the samples of sea-water examined had been drawn from the open sea, the mode of collecting and preserving them was frequently so open to objection that, even assuming the methods adopted for their examination to have been in every respect trustworthy, these early experiments will not bear comparison with those of modern date, performed with the far superior apparatus since devised.

Our knowledge therefore, till but a few years since, of the distribution of air in ocean-water, must be said to have continued very imperfect; and the reason is found in the numerous difficulties everywhere encountered when proceeding to investigate so intricate a subject. From the great mobility of the atmosphere, experiments in a few localities only will suffice to determine the general composition of air; but with sea-water the case is different. Water being far less fluid than air, many observations are obviously needed, since the greatest importance must be attached to geographical position. Hence, samples of sea-water had to be brought home from distant regions, and in that case, by being allowed to stand over for a comparatively long period, left exposed to all manner of disturbing influences; or the observations were taken on board, and experiments performed to the best of the analyst's ability, in spite of the numerous drawbacks entailed by the motion of the vessel. But, though many of the earlier chemists would, when at sea, no doubt have felt an interest in contributing to solve the problem of the distribution of air in the water of the ocean, they almost inva-

ser paa Reiser at give Bidrag til Løsningen af Spørgsmaalet om Fordelingen af Luften i Havet, da har Anledningen dertil næsten bestandig manglet. Først ved de i de senere Tider hyppigt udsendte Expeditioner, hvormed der har været givet Chemikere Anledning til at medfølge, har det været muligt mere detailleret at studere disse Ting. Ved disse Expeditioner har Formaalet udelukkende været videnskabelig Undersøgelse af Havet, og der har derfor med Hensyn paa Udrustningen altid været lagt megen Vind paa ved hensigtsmæssige Foranstaltninger og omhyggelige Forberedelser at fremme dette Formaal saa meget som muligt, og det er derfor klart, at disse Expeditioner maa have den største Betydning for den chemiske Undersøgelse af Havene specielt, hvor Talen er om saadanne Observationer, der ligesom Bestemmelser af Gasarterne ikke taale Opsættelse, men nødvendigvis maa udføres øieblikkelig efter at Vandprøven er øst. Saaledes maa aabenbart de under disse Omstændigheder udførte Observationer faa størst Vægt, hvor det dreier sig om at skaffe Oplysninger om Gasarterne i Søvandet, udenat det dog derfor vil findes paa urette Plads her at give en kort Oversigt ogsaa over de herover udførte ældre Undersøgelser.

De tidligste Undersøgelser, der mig bekjendt ere gjorte over Luften i Søvandet, udførtes i 1838 af Frémy[1] paa nogle Vandprøver, der over et Aar forud vare bleven optagne paa den franske Expedition med 'La Bonite' i 1836 og 37. Vandprøverne bestode dels af Overfladevand dels af Vand fra forskjellige Dyb indtil 450 franske Favne og vare optagne med et af Biot opfundet Apparat.[2]

Ved Analysen af den udkogte Gas absorberede Frémy Kulsyren med Kalilud og Surstoffet med Phosphor. Resultaterne ansaaes allerede af Frémy selv for upaalidelige og de staa saa bestemt i Strid med alle nyere Angivelser, at man med temmelig stor Sikkerhed kan antage, at det lange Tidsrum mellem Vandprøvernes Øsning og deres Undersøgelse har gjort dem fuldstændig ubrugbare.

I 1843 udførte Morren[3] nogle Undersøgelser af Overfladevandet ved Saint-Malo nærmest i den Hensigt at paavise Sollysets Indflydelse paa den relative Sammensætning af den af Vandet absorberede Luft. Han kom i den Henseende til det Resultat, at Surstofmængden fandtes størst og Kulsyremængden mindst ved klart Sollys, hvorimod omvendt Surstofmængden fandtes mindst og Kulsyremængden størst ved mørkt overskyet Veir. Vandprøverne undersøgtes ikke paa Stedet, men sendtes til Rennes, hvor de af Morren udkogtes i Kolber paa 4.5 Litre. Den udkogte Gas ledes gjennem Kautschukledning over i en Flaske, hvori Gasarterne opsamledes over Vand. Ved Analysen af Gasen anvendte han til Absorbtion af Kulsyren Kalilud og for-

[1] Compt. rend. 6 — 616.
[2] Pogg. Ann. 37 — 416.
[3] Ann. Chim. Phys. [3] — 12 — 5.

riably lacked the means. Not till chemists had been sent out on the numerous Expeditions dispatched of late years to all quarters of the globe, was it possible to study this subject in detail. The sole object of such Expeditions having been the scientific investigation of the ocean, they were naturally fitted out with the greatest possible care, being furnished with the latest and most improved apparatus, and every necessary aid and appliance. It is obvious, therefore, that these Expeditions must largely contribute to our chemical knowledge of the ocean, more particularly with regard to observations which, like the determination of gaseous bodies, will not brook delay, but must be taken immediately the sample of water has been drawn. Hence, very great weight should be attached to observations instituted under such circumstances, viz. those that relate to the determination of gaseous bodies in sea-water. It will not, however, be out of place, briefly to notice some of the earlier observations undertaken with that object in view.

The earliest experiments, so far as I am aware, relating to the air in sea-water, were instituted in 1838, by Frémy,[1] with samples of water drawn more than a year before on the French Expedition with the 'Bonite,' in 1836 and 1837. These samples of water consisted partly of surface-water, partly of water from various depths, the greatest being 450 French fathoms; and were collected with an apparatus devised by Biot.[2]

When analysing the gas driven off, the carbonic acid was absorbed in a lye of potash, the oxygen being consumed with phosphorus. But Frémy himself did not regard as trustworthy the results of this process; and they have proved so decidedly at variance with those of all later observations, that his samples of water, owing to the length of time for which they had been preserved previous to examination, had no doubt become utterly worthless for experimental purposes.

In 1843, Morren[3] instituted a series of experiments with surface-water, near St. Malo, chiefly with the object of determining the influence of solar light on the composition of the air absorbed by sea-water. He found the proportion of oxygen to be greatest, and that of carbonic acid least, in bright weather; whereas the proportion of oxygen was least, and that of carbonic acid greatest, with a dark, cloudy sky. The samples of water were not examined on the spot, but taken to Rennes, and there boiled by Morren, in matrasses containing 4.5 litre. The gas driven off during the process was conducted through a caoutschouc tube into a phial, and there collected over water. When analysing the gas, Morren used a lye of

[1] Compt. rend. 6, p. 616.
[2] Pogg. Ann. 37, p. 416.
[3] Ann. Chim. Phys. [3], 12, p. 5.

brændte Surstofgasen med overskydende Vandstof. Han brugte ogsaa her som Spærrevædske Vand, som paa Forhaand var mættet med Luft, og det kan saaledes ikke forundre, at de Resultater, han erholdt, vise temmelig betydelige Afvigelser. Surstofmængden varierer saaledes fra 39.5 til 31.0 og udgjør i Middel 34.7 % af den samlede Surstof-Kvælstofmængde, medens denne varierer mellem 20.0 og 30.5 og i Middel udgjør 24.5 CC. pr. Litre af det udkogte Vand. Som man heraf ser, svarer den midlere Surstofprocent meget nøie med det af Bunsen senere for destilleret Vand opstillede Tal, hvorimod de Tal, Morren opfører som Udtryk for den samlede Surstof-Kvælstofmængde, ingen nøiagtig fixeret Betydning have, da han intetsteds angiver den Barometerstand og Temperatur, hvortil han har reduceret sine Gasvolumina.

Nogle Aar senere i 1846 gjenoptog Lewy[1] Morrens Undersøgelser paa nogle Vandprøver, som han øste ved Langrune i Nordost for Saint-Malo, og anvendte for at kunne sammenligne sine Resultater med Morrens nøiagtig den af ham beskrevne Arbeidsmethode. Hans Resultater vise ogsaa, naar man tager Hensyn til, at Vandprøverne alle skrive sig fra samme Sted, ikke ubetydelige om end meget mindre Afvigelser, som han ligesom Morren tilskriver Sollysets Indflydelse. Surstofmængden varier hos ham fra 35.4 til 32.4 og udgjør i Middel 33.6 % af den samlede Surstof-Kvælstofmængde, som gjennemsnitlig beløber sig til 17.3 CC. pr. Litre og ikke overskrider Grændserne 18.9 og 16.3. Heller ikke Lewy har nærmere fixeret Betydningen af de opførte Gasvolumina. Der har forresten i hans Tabel indsneget sig meningsforvirrende Regnefeil, som har givet Anledning til, at han er bleven misforstaaet.

I 1851 har endvidere A. Hayes[2] offentliggjort nogle Udtalelser om Fordelingen af Luften i Søvandet dog uden at vedføie sine Originalobservationer. Ifølge ham findes i Vand fra større Dyb altid en betragtelig mindre Mængde Surstof end i Overfladevandet, en Regel, som overalt holdt stik saavel i den hede som tempererede Zone, naar undtages i Golfstrømmen, hvor den stærke Bevægelse i Vandet kunde antages at forstyrre den almindelige Ligevægt. Han fandt ogsaa efter Storme en betydelig større Surstofmængde i Overfladevandet.

I 1855 udførte M. F. Pisani[3] nogle Undersøgelser af Saltene i Overfladevandet ved Bujuk-Déré og bestemte samtidig de i Vandet indeholdte Gasarter. Resultaterne findes sammenstillede i nedenstaaende Tabel, hvor Volumet er reduceret til 0° og 760mm Tryk og udtrykt som CC. pr. Litre Vand.

[1] Ann. Chim. Phys. [3] — 17. Ann. Chem. Pharm. 58 — 326.
[2] Sillim. Amer. Journ. [2] — 11 — 241.
[3] Compt. rend. 41 — 532.

potash for absorbing the carbonic acid, and consumed the oxygen with a surplus of hydrogen. Here, too, the confining fluid was water, previously saturated with air; and hence it is not surprising, that the results obtained should have been found to vary considerably. Thus, for instance, the amount of oxygen varies between 39.5 and and 31.0 per cent, the mean proportion being 34.7 of the total amount of oxygen and nitrogen; while the latter ranges from 20.0 to 30.5, giving a mean proportion of 24.5cc per litre. The mean percentage of oxygen agrees, therefore, very closely with the proportion afterwards found by Bunsen for distilled water; whereas no definite importance can be attached to Morren's figures representing the total amount of oxygen and nitrogen, since that observer does not anywhere state to what temperature and atmospheric pressure he had reduced the volume of the gas.

Some years after, in 1846, Lewy[1] repeated Morren's experiments, with samples of water drawn at Langrune, north-east of Saint-Malo, adopting, the better to compare his results with those of Morren, precisely the same mode of operation. The results obtained by this chemist, seeing that the samples of water were all of them from the same locality, vary, too, considerably, though by no means to the same extent, — which he, in common with Morren, ascribes to the influence of solar light. The amount of oxygen ranges from 35.4 to 32.4—33.6 per cent, being the mean proportion of the total amount of oxygen and nitrogen, which averages 17.3cc per litre, having in no case passed the limits 18.9 and 16.3. Lewy, too, omits to give the factors determining the volume of the gas. Moreover, divers perplexing errors have slipped into his Table; and hence he has been misunderstood by some.

In 1851, A. Hayes[2] published a paper on the distribution of air in sea-water, without however embodying his original observations. According to the observations of that chemist, the amount of oxygen in water drawn from great depths is always appreciably less than that in surface-water, a rule which holds good for all seas both of the torrid and the temperate zones, with the exception of the Gulf Stream, where the strong current may be supposed to exert a disturbing influence. After a heavy gale of wind, too, the proportion of oxygen in the surface-water was found to be much greater.

In 1855, M. F. Pisani[3] instituted a series of observations near Bujuk-Déré on the salts in surface-water, and also determined the gaseous bodies it contained. His results are given in the following Table, the volume being reduced to a temperature of 0° and a pressure of 760mm, expressed in cubic centimetres per litre.

[1] Ann. Chim. Phys. [3], 17; Ann. Chem. Pharm. 58, p. 326.
[2] Sillim. Amer. Journ. [2], 11, p. 241.
[3] Compt. rend. 41, p. 532.

$O + N$ pr. Litre		16.0	16.2
$O + N = 100$	O %	31.4	33.2
	N %	68.5	66.8

I Aaret 1869 udgik fra England Porcupineexpeditionen, hvor der for første Gang foruden de øvrige videnskabelige Arbeider ogsaa foresloges udført mere omfattende chemiske Undersøgelser. Man besluttede her at benytte den udmærkede Anledning til ved talrige Forsøg saavel med Overfladevand som Vand fra større Dyb at skaffe sig Oplysning om de Fluctuationer, som optræde saavel i de absolute som relative Mængder af de i Søvandet opløste Gasarter. Forat undgaa de Feil, som nødvendigvis maatte indsnige sig, naar de til Gasanalyser bestemte Vandprøver opbevaredes i længere Tid før Undersøgelsen, bestemte man sig her for den Udvei at foretage Gasanalyserne ombord. Til Optagelse af de fra større Dyb stammende Vandprøver benyttedes en meget simpel Vandhenter bestaaende af en hul Metalcylinder med letbevægelige opadslaaende Kegleventiler, et Apparat, hvis Paalidelighed senere Undersøgelser giver Anledning til at betvivle. Udkogningen og Opsamlingen af Gasarterne foretoges i alt Væsentligt som ved de tidligere beskrevne Forsøg, og anvendtes under Analysen til Absorbtion af Kulsyre og Surstof Kalihydrat og pyrogallussur Kali. Det siger sig selv, at de paa denne Maade erholdte Resultater maatte være beheftede med meget betydelige Observationsfeil, hvad der ogsaa tydeligst vises af de store Afvigelser mellem de af forskjellige Observatorer efter denne Fremgangsmaade udførte Bestemmelser. Som Udtryk for Sammensætningen af den af Overfladevandet udkogte Luft fandt nemlig de tre Chemikere, som paa de tre Togter, hvori denne Expedition deltes, efter hinanden udførte de chemiske Arbeider, følgende Tal:[1]

W. L. Carpenter	31.6 %	O	mod	68.4 %	N.
Hunter	36.4 -	O		63.6 -	N.
P. Herbert Carpenter	30.5 -	O		69.5 -	N.

Dette er kun de af de enkelte Observationer udledede Middelværdier, men, som man ser, er allerede Afvigelserne mellem disse overmaade store, medens de enkelte Bestemmelser, som ikke findes opførte, varierer mellem langt videre Grændser. Saaledes opføres som Ydergrændser for Variationerne af Surstofmængden i Overfladevandet Maximum 45.3 og Minimum 14.0 % af den samlede Gasmængde, Kulsyren iberegnet.

Porcupineexpeditionens Chemikere ansaa selv sine Resultater upaalidelige, dog mindre paa Grund af Mangler ved Arbeidsmethoderne, end fordi den af dem benyttede Vandhenter tillod Undvigelsen af den Luft, som de mente kunde udvikle sig, naar Vandet fra de større Dyb naaede op til det ved Overfladen herskende mindre Tryk. De tog forresten sin Tilflugt ogsaa til andre Midler for at forklare

[1] Proc. Roy. Soc. 18 — 397.

$O + N$ pr. Litre		16.0	16.2
$O + N = 100$	O p.ct.	31.4	33.2
	N p.ct.	68.5	66.8

In the year 1869, the 'Porcupine' Expedition was dispatched by the British Government, and it was now proposed, for the first time, to institute a series of chemical experiments on a more comprehensive scale than any hitherto performed. By taking advantage of this excellent opportunity to examine numerous samples of sea-water, both from the surface and from great depths, the fluctuations that occur alike in the absolute and the relative amounts of gaseous bodies in ocean-water might be effectively investigated. In order to guard against the error that must necessarily arise when the samples of water are preserved for any length of time previous to examination, it was resolved to undertake all analyses of gas on board. For obtaining samples of water from great depths, a very simple instrument was used, consisting of a hollow metal cylinder, furnished with conical-shaped valves, opening above, an apparatus the trustworthiness of which subsequent experiments have shown reason to doubt. The gas was boiled out and collected by a process essentially similar to that adopted for the experiments previously described, the carbonic acid and the oxygen having been absorbed by hydrate of potash and pyrogallic acid. As a matter of course, very considerable errors of observation would attach to results obtained by this method, the best proof of which lies in the extent to which the determinations of different observers performed by this mode of operation are found to vary. For instance, the three chemists who successively accompanied the Expedition on the three voyages into which it was divided, express the composition of the air boiled out of surface-water by the following figures:[1] —

W. L. Carpenter	31.6 p.ct.	O	and	68.4 p.ct.	N.
Hunter	36.4 -	O	-	63.6 -	N.
P. Herbert Carpenter	30.5 -	O	-	69.5 -	N.

These amounts, however, are the mean values deduced from the several observations, and yet they vary exceedingly; the individual determinations, which are not given, must obviously have ranged between far wider limits. Thus, the extreme limits between which the amount of oxygen was found to vary in surface-water, is stated to have been 45.3 (maximum) and 14.0 (minimum) per cent of the total amount of gas, including the carbonic acid.

The chemists who accompained the 'Porcupine' Expedition did not even themselves regard the results obtained as trustworthy, less however on the ground of possible defects in the modes of operation, than because the the apparatus used for collecting the water admits of the escape of air which, in their opinion, may be liberated on water drawn from great depths reaching the surface, where the atmos-

[1] Proc. Roy. Soc. 18, p. 397.

de observerede store Afvigelser, saaledes tilskreves stærke Bevægelser af Havoverfladen enten ved Storme eller paa anden Maade den Evne at forøge Surstofmængden og forringe Kulsyremængden, ligesom rigt Dyreliv ogsaa tilskreves en meget stor Indflydelse paa Sammensætningen af den i Søvandet opløste Luft.

I 1871 udgik atter igjen denne Gang fra Tyskland en Expedition til Undersøgelse af Østersøen, hvormed som Chemiker fulgte Dr. O. Jacobsen. Med Resultaterne af de fra de tidligere Expeditioner hidrørende Gasbestemmelser for Øie besluttede han sig hverken for den ene eller den anden af de ved Bonite eller Porcupineexpeditionen anvendte Fremgangsmaader men slog ind paa en Middelvei, den eneste, som i dette Tilfælde kunde føre til paalidelige Resultater.

Han delte Undersøgelserne i to Dele og udførte den uopsættelige Del af dem nemlig Gasarternes Udkogning strax, medens han, indseende Umuligheden af at udføre tilfredsstillende Gasanalyser ombord paa et Fartøi i aaben Sø, opsatte deres nærmere Undersøgelse til Hjemkomsten. Desværre gav Mangelen af en til Optagelse af Dybvandsprøver egnet paalidelig Vandhenter Anledning til, at det 1ste Aars Udbytte af denne Expedition for Gasanalysernes Vedkommende reducerede sig til blot og bart Indsamling af den Erfaring, som senere skulde komme til Anvendelse ved det Aaret efter foretagne Togt i Nordsøen. Manglerne ved den paa Porcupineexpeditionen benyttede Vandhenter havde nemlig bevæget Jacobsen til ogsaa til Øsning af de for Gasanalyser bestemte Vandprøver at benytte en Vandhenter, der nedsænkedes fyldt med Luft. Naar nu Apparatet i Dybet aabnedes, absorberedes under det der herskende store Tryk momentant en Del af den nedbragte atmosphæriske Luft, hvorved de paa disse Vandprøver udførte Gasanalyser bleve saa upaalidelige, at der ikke engang værdigedes dem en Offentliggjørelse.

De paa Østersøtogtet i 1871 indhøstede Erfaringer, muliggjorde det imidlertid for Jacobsen ved en omhyggelig Forberedelse til den i 1872 foretagne Expedition i Nordsøen at overvinde eller omgaa de Vanskeligheder, som havde bevirket Manglerne ved de paa Porcupineexpeditionen foretagne Undersøgelser, og det lykkedes ham denne Gang som Resultat af sine Arbeider at offentliggjøre en Afhandling,[1] som giver en Række af vore Tiders Fordringer strengt tilfredsstillende Oplysninger om Luften i Søvandet. Til Optagelse af de til Gasanalyser bestemte Vandprøver fra Dybet tjente paa Nordsøtogtet et af Dr. H. A. Meyer angivet Apparat[2] bestaaende af en tung Metalcylinder, som ved Udløsning i det bestemte Dyb faldt ned over to vel islebne koniske Ventiler, og derved afspærrede det mellem disse

[1] Ann. Chem. Pharm. 167 — 1; Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1872—73 — 43.

[2] Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel 1872—73 —. 5.

pheric pressure is less. But they had recourse to other means whereby to explain the great differences observed, ascribing to the state of violent agitation into which the surface of the ocean is thrown by heavy storms, or to some other adequate cause, the ability of increasing the proportion of oxygen and diminishing that of carbonic acid; an abundance of animal life, too, was believed to exert very great influence on the composition of the air absorbed in sea-water.

In 1871, an Expedition was despatched from Germany for the investigation of the Baltic, Dr. O. Jacobsen accompanying it as chemist. Warned by the unsatisfactory results of former gas-analyses, he resolved to adopt neither of the methods resorted to on the 'Bonite' and 'Porcupine' Expeditions, but rather to take a middle course, which indeed held out the only prospect of success.

Accordingly, he divided his observations. Experiments admitting of no delay, such as boiling off the gas, were performed at once, whereas all analyses of gas, impossible as it is found to operate satisfactorily on board a vessel in the open sea, were deferred till his return home. Unfortunately, the want of a trustworthy apparatus for collecting samples of water from great depths, confined the results obtained on the first voyage of the Expedition, as regards analyses of gas, to the mere acquisition of experience, which, however, there was ample opportunity of applying on the cruise undertaken the following year in the North Sea. The defective construction of the instrument employed for collecting water on the 'Porcupine' Expedition had induced Jacobsen to make use of an apparatus which, even when drawing water for gas-analyses, was sunk full of air. Now, on opening this apparatus at the required depth, some portion of the air it contains will, by reason of the great pressure, be momentarily absorbed; and hence all analyses of gas with such samples of water proved to that extent defective as to be not even deemed worthy of publication.

Meanwhile, taking advantage of the experience acquired in 1871 on the cruise in the Baltic, Dr. Jacobsen succeeded, after careful preparation to meet the requirements of the Expedition undertaken in 1872 to the North Sea, in surmounting or evading the difficulties experienced on the 'Porcupine' Expedition, and was enabled, as the result of his labours, to publish a treatise[1] on the air present in sea-water recording a series of eminently satisfactory results. For collecting samples of water wherewith to undertake analyses of gas in water from the bottom, or from great depths, an apparatus, described by Dr. H. A. Meyer, was made use of on the cruise in the North Sea.[2] It consists of a heavy metal cylinder, which, at the required depth, will drop down on two accurately fitted conical valves, cutting off all com-

[1] Ann. Chem. Pharm. 167, p. 1; Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1872—73, p. 43.

[2] Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1872—73, p. 5.

beliggende Vandlag. Udløsningen foregik enten ved Apparatets Anslag mod Bunden eller i intermediære Dyb ved et langs Linen nedsænket Lod.

Ved Uddrivelsen af de i Vandet indeholdte Gasarter anvendte Jacobsen Bunsens Princip, idet Vandet kogtes i

munication with the outside water. The detachment was effected either by the instrument striking the bottom, or, at intermediate depths, by running a weight down the line.

For expelling the gas contained in the water, Jacobsen made choice of Bunsen's method, boiling the water in

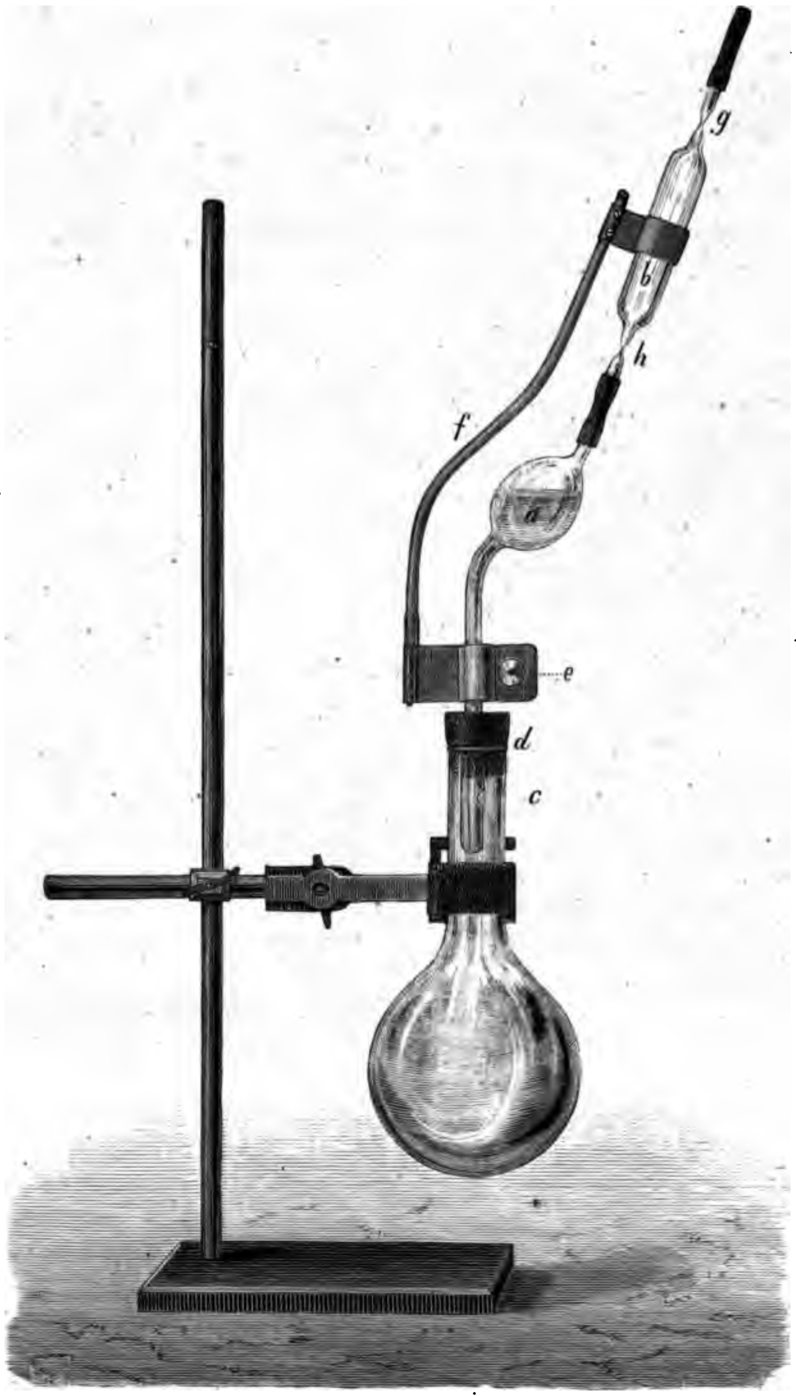


Fig. 1.

et ved Vanddamp frembragt Vacuum, og construerede i Forbindelse med Dr. H. Behrens i dette Øiemed et Apparat, som i Simpelhed og Paalidelighed Intet lader tilbage at ønske. Apparatet, som findes afbildet i Figur 1, har af Jacobsen faaet følgende Beskrivelse:

a vacuum created by steam; and to meet the requirements of this process, he devised, with the assistance of Dr. H. Behrens, an apparatus which in trustworthiness and simplicity of construction leaves nothing to be desired. This apparatus, of which a drawing is given in Fig. 1, Dr. Jacobsen has described as follows: —

Nachdem nun die Oeffnung *c* bis eben unter den Pfropfen hinabgeschoben ist, wird das Wasserbad erwärmt und der Inhalt des Kolbens in heftigem Sieden erhalten. Nach einiger Zeit hat sich im oberen Theil des Kolbenhalses ein freier Raum gebildet, in welchen die Dampfblasen mit Geräusch hineinschlagen. Man bringt durch Entfernen der Wärmequelle oder durch kurzes Herausheben des Apparates aus dem Wasserbade das Wasser aus der Siedekugel in den Kolben zurück und wiederholt dieses Ervärmen und theilweise Abkühlen des Kolbenhalses noch zweimal, wodurch binnen verhältnissmässig kurzer Zeit eine sehr vollständige Austreibung der Luft bewirkt wird.

Es ist sehr leicht, schliesslich das Wasser bis zur vollständigen Anfüllung der Siedekugel steigen zu lassen, worauf man durch Aufziehen derselben den Verschluss herstellt und das Sammelrohr nun auch bei *h* abschmilzt.

Das Sammeln der Gase mittelst dieses Apparates machte auch bei ziemlich stark bewegter See keine Schwierigkeit.

Gewöhnlich wurden 900 CC Wasser zur Auskochung verwendet."

Ved Hjælp af dette Apparat indsmeltede Jacobsen paa Nordsøtogtet 73 Luftprøver, som efter Hjemkomsten analyseredes efter Bunsens Methode, idet Kulsyren fjernedes med Kali og Surstoffet bestemtes ved Forbrænding med overskydende Vandstof. Han sammenstiller sine Resultater i en Tabel, hvor han i Modsætning til de tidligere Forfattere betragter den kulsyrefrie Luft og Kulsyren hver for sig,[1] saaledes beregnes Surstof og Kvælstofmængderne som Procenter af den kulsyrefrie Luft, der opføres som CC pr. Litre udkogt Vand reduceret til 0^{0} og 760^{mm} Tryk. Ifølge denne Tabel hersker der en ganske mærkelig gjennemført Ensartethed i Sammensætningen af den Luft, der er uddrevet af de Vandprøver, som have befundet sig under samme physikalske Forholde, saaledes ligger Surstofprocenten i alle de 24 Luftprøver, som stamme fra Overfladevandet, tiltrods for at de skrive sig fra meget forskjellige Localiteter, mellem de meget snævre Grændser af 34.14 og 33.64, og naar denne Overensstemmelse ikke i samme Udstrækning er fundet at gaa igjen i de dybere Lag, da har dette sin Forklaring i en ujevn Circulation. Naar Surstofmængden overalt i Dybet er funden lig eller noget mindre end i Overfladen, da kan det vel ikke være tvivlsomt, at dette skriver sig fra Surstoffets Forbrug til Oxydation af de i Søvandet forekommende organiske Plante- og Dyrerester samt til Sødyrenes Aandeproces, saaledes som det af Jacobsen udtales med følgende Ord: "Der Zusammenhang dieses Unterschiedes ist leicht zu deuten. In dem schwereren Wasser, welches ohne erhebliche Beimischung aus höhe-

[1] Naar jeg her overalt har anvendt denne Jacobsens Fremstillingsmaade og ifølge denne omregnet de ældre Forfatteres Opgaver, hvor Gasmængderne overalt ere fremstillede som Procenter af den samlede Surstof-Kvælstof-Kulsyremængde, da vil Grunden hertil fremgaa af min senere Afhandling "Om Kulsyren i Søvandet."

Nachdem nun die Oeffnung *c* bis eben unter den Pfropfen hinabgeschoben ist, wird das Wasserbad erwärmt und der Einhalt des Kolbens in heftigem Sieden erhalten. Nach einiger Zeit hat sich im oberen Theil des Kolbenhalses ein freier Raum gebildet, in welchen die Dampfblasen mit Geräusch hineinschlagen. Man bringt durch Entfernen der Wärmequelle oder durch kurzes Herausheben des Apparates aus dem Wasserbade das Wasser aus der Siedekugel in den Kolben zurück und wiederholt dieses Erwärmen und theilweise Abkühlen des Kolbenhalses noch zweimal, wodurch binnen verhältnissmässig kurzer Zeit eine sehr vollständige Austreibung der Luft bewirkt wird.

Es ist sehr leicht, schliesslich das Wasser bis zur vollständigen Anfüllung der Siedekugel steigen zu lassen, worauf man durch Aufziehen derselben den Verschluss herstellt und das Sammelrohr nun auch bei *h* abschmilzt.

Das Sammeln der Gase mittelst dieses Apparates machte auch bei ziemlich stark bewegter See keine Schwierigkeit.

Gewöhnlich wurden 900 CC. Wasser zur Auskochung verwendet."

With this apparatus Jacobsen collected on the cruise in the North Sea 73 samples of air, which, after the return of the Expedition, were analysed by Bunsen's method, potash being used for absorbing the carbonic acid, and the oxygen consumed with a surplus of hydrogen. His results are set forth in a Table, where, reversing the custom of earlier authors, he refers separately to the carbonic acid and the air free from that body;[1] thus, for instance, the respective amounts of oxygen and nitrogen will be found computed as percentages of the air free from carbonic acid, which is given in cc. per litre of the water examined, reduced to a temperature of 0^{0} and a pressure of 760^{mm}. According to this Table, a truly remarkable uniformity prevails in the composition of the air expelled from samples of sea-water which have been exposed to the same physical influences; thus, for instance, the percentage of oxygen in the 24 samples of air derived from surface-water, was found, notwithstanding the collection of the latter in widely different localities, to range between the exceedingly narrow limits of 34.14 and 33.64; and though equal agreement does not extend to the deeper-lying strata, this may be accounted for by irregularity of circulation. That the amount of oxygen at the bottom, or in great depths, should invariably prove equal to, or somewhat less than, that at the surface, is a phenomenon the cause of which must unquestionably be ascribed to the consumption of that gas in the oxidation of organic remains, and for the support of the res-

[1] The reason that induced me to adopt exclusively Jacobsen's mode of representation, and by the standard of that process to recompute the results of earlier observers, who invariably give the proportions of the gases determined as percentages of the total amount of oxygen, nitrogen, and carbonic acid, will appear in my next Memoir on the carbonic acid present in sea-water.

ren Schichten sehr lange in der Tiefe verweilt, wird ohne genügenden Ersatz fortwährend Sauerstoff verbraucht zur Oxydation der im Wasser und besonders am Meeresgrunde vorhandenen oxydirbaren Stoffe, — in wahrscheinlich weit untergeordnetem Grade auch durch die Athmung der Thiere."

Men de herved foranledigede Afvigelser ere ikke meget store, idet Surstofprocenten, bortseet fra nogle faa Undtagelser, ligger indesluttet mellem 30 og 34, saaledes at den som Regel aftager med Dybet.

Jacobsens Observationer, der vare udførte under de mest forskjelligartede Omstændigheder, vise ogsaa paa det Bestemteste, at de tidligere gjorte Antagelser, om at Sollyset og Stormene eller i det Hele taget de meteorologiske Forholde skulde spille nogen fremtrædende Rolle ligeoverfor den relative Sammensætning af Overfladevandsluften, vare fuldstændig ubegrundede, i ethvert Fald vise de store Overensstemmelser, at disse Factorers Indflydelse maatte være meget ringe.

Med Hensyn paa den absolute Mængde af den Luft, der indeholdes i de fra forskjellige Dyb optagne Vandprøver, da viser den sig at tiltage med Dybet, noget der imidlertid let lader sig forklare ved Temperaturens Aftagen med Dybet, uden at det er fornødent at tage sin Tilflugt til de store Tryk. Der blev ogsaa paa Pomeraniaexpeditionen for at bevise Urigtigheden af den tidligere paa flere Steder udtalte Formodning, om at Luftgehalten i de store Dyb skulde staa i Forhold til det der herskende større Tryk, foretaget specielle Experimenter med en af Dr. Behrens og Jacobsen construeret Vandhenter af Kautschuk. Denne sammenklemtes først mest muligt, hvorpaa den sidste Rest Luft uddreves af den ved Hjælp af Kviksølv, og nedsænkedes derefter fuldstændig lufttom og lufttæt igjenlukket. Først i Dybet ved Apparatets Anslag mod Bund aabnedes det, udspændtes og fyldtes med Vand, hvorpaa det atter lufttæt igjenlukket og fyldt med Vand ankom til Overfladen. Det viste sig altid, at de med dette Apparat optagne Vandprøver ikke indeholdt mere Luft, end de ved Vandprøvens Temperatur kunde holde opløst under almindeligt Atmosphæretryk. At dette maatte være saa, kunde man allerede være berettiget til at slutte af nogle Forsøg, som Aimé[1] i 1843 udførte. Han anvendte et i den ene Ende aabent Glasrør, som nedsænkedes fyldt med Kviksølv og i det bestemte Dyb vendtes omkring, hvorved Kviksølvet i Glasrøret delvis erstattedes af Vand paa en saadan Maade, at dette afspærredes af Kviksølvet, der optoges af en nedenunder anbragt passende Beholder. Som Resultat af de med dette Apparat udførte Forsøg udtalte Aimé den Sats, at den Mængde Luft, som indeholdtes i en bestemt Mængde Søvand, i alle Dyb var meget nær den samme.

[1] Ann. Chim. Phys. [3] — 7 — 497. Pogg. Ann. 30 — 412.

piratory process in marine animals, as stated by Dr. Jacobsen in the following words: — "Der Zusammenhang dieses Unterschiedes ist leicht zu deuten. In dem schwereren Wasser, welches ohne erhebliche Beimischung aus höheren Schichten sehr lange in der Tiefe verweilt, wird ohne genügenden Ersatz fortwährend Sauerstoff verbraucht zur Oxydation der im Wasser und besonders am Meeresgrunde vorhandenen oxydirbaren Stoffe, — in wahrscheinlich weit untergeordnetem Grade auch durch die Athmung der Thiere."

But the differences thus occasioned are not very great, since the percentage of oxygen, with but few exceptions, ranges from 30 to 34, as a rule diminishing with the depth.

Moreover, Jacobsen's observations, instituted under circumstances the most diverse, furnish incontestible proof, that the views of earlier authors, according to which the effect of solar light and storms, or indeed meteorological influence generally, was assumed to play an important part in modifying the composition of the air in surface-water, were wholly unfounded; nay, the extent to which the results based on that hypothesis are found to vary, will of itself show the comparative insignificance of such factors.

As regards the absolute amount of air contained in samples of water collected from different strata, this is found to increase with the depth, — a fact sufficiently obvious from the temperature diminishing as the depth increases, without needing to seek an explanation in the greater pressure. And with the object of showing that the proportion of air present in sea-water at great depths, is not, as assumed by some, to any appreciable extent dependent on the greater pressure prevailing there, a special series of experiments was instituted on the 'Pomerania' Expedition, with an apparatus for collecting water constructed of caoutschouc by Drs. Behrens and Jacobsen. This instrument was first pressed flat, and then sunk, after the air still remaining in it had been expelled by means of mercury, perfectly air-tight. On its striking the bottom, it opened and filled with water, after which it again closed, and was then brought up to the surface, air-tight as before. The samples of water collected in this apparatus were never found to contain more air than would be absorbed, with the same temperature, at the surface. That such must be the case, there was indeed reason to infer from the experiments instituted by Aimé[1] in 1843. Aimé made use of a glass tube, which, open at the upper extremity, was sunk full of mercury, and at the required depth inverted, causing part of the mercury in the tube to be replaced by water, in such manner that the mercury, flowing into a receiver of proper size and shape, prevented its escape. As the result of the experiments performed with this instrument, Aimé ventured to assume, that the proportion of air contained in a given quantity of sea-water, is at all depths very nearly the same.

[1] Ann. Chim. Phys. [3], 7, p. 497; Pogg. Ann. 30, p. 412.

I Aaret 1873 udgik atter fra England en Expedition, Challengerexpeditionen, som i et Tidsrum af 3 Aar skulde undersøge baade de æquatoriale og antarktiske Farvande. Med denne Expedition fulgte som Chemiker J. Y. Buchanan, som besluttede sig til at anvende de paa Pomerania-expeditionen benyttede Methoder og Apparater saa godt som uden Modifikationer. Resultaterne af hans Undersøgelser ere, saavidt jeg ved, endnu ikke offentliggjorte i sine Enkeltheder, medens der dog er gjort nogle foreløbige Meddelelser, hvorefter man vil kunne danne sig et Begreb om de Slutninger, hvortil hans Observationer ville føre.

Han finder[1], at Surstofmængden i Overfladevandet varierer mellem 33 og 35 % af den samlede Surstof-Kvælstofmængde, saaledes at den største Mængde er fundet (baade relativt og absolut) i Vandprøver øste i Nærheden af den sydlige Polarcirkel og den mindste i Pasatvindegnene. Hvad angaar de under Overfladen liggende Lag, da har han observeret det mærkelige Factum, at Surstofprocenten aftager nedover indtil et Dyb af 300 Favne, hvor den opnaar et Minimum for atter igjen at stige, saaledes som det fremgaar af følgende Tabel.

Dybde i engelske Favne.	0	25	50	100	200	300	400	800	Derover.
$O + N = 100$ O %	33.7	33.4	32.2	30.2	33.4	11.4	15.5	22.6	23.5

Om den absolute Mængde af de af hans Vandprøver udkogte Gasarter findes paa dette Sted Intet, hvorimod der senere er bleven offentliggjort følgende Tabel[2].

Dybde i Fod.	CC. O per Litre.	Midlere Temperatur i °C. t.	CC. N per Litre N_1.	CC. N per Litre destill. Vand ved Temperat. t. Bunsen N_2.	$N_2 - N_1$
600	4.24	14.°6	11.26	11.75	0.49
1200	3.59	13. 0	11.71	11.92	0.21
1800	1.67	6. 9	13.00	13.45	0.45
2400	2.41	5. 1	13.10	14.00	0.90
4800	4.06	2. 5	13.82	15.00	1.14
derover.	—	1. 5	14.37	15.40	1.03

Hermed er i Korthed gjengivet det Vigtigste af de til Dato fremkomne Bidrag til Løsningen af Spørgsmaalet om Luften i Søvandet.

I Vaaren 1876, da man i Norge var beskjæftiget med Udrustningen af den Expedition, som var besluttet udsendt for i Sommermaanederne af Aarene 1876—77 og 78 at

[1] The Voyage of the 'Challenger.' The 'Atlantic.' 2 — 366.
[2] Ber. Berl. chem. Ges. 11 — 410.

In the year 1873, another Expedition was dispatched, from England, with H. M. S. 'Challenger,' its object being the investigation, during a period of 3 years, both of the Equatorial and the Antarctic Seas. As chemist to this Expedition, had been secured the services of J. Y. Buchanan, who resolved to adopt the methods and apparatus employed on the 'Pomerania' Expedition, almost without modification. The results of his labours are not yet, I believe, published in detail; preliminary papers have, however, appeared, from which we can form some general idea of his results.

Buchanan found[1] the proportion of oxygen in surface-water to vary between 33 and 35 per cent of the total amount of oxygen and nitrogen; it was greatest (both relatively and absolutely) in the samples of water drawn near the Antarctic Circle, and smallest in those collected within the region of the trade winds. As regards the proportion of oxygen in water below the surface, he observed the very remarkable fact, that it generally diminshes down to a depth of 300 fathoms, where a minimum is reached, and then begins to increase, as shown by the following Table.

Depth in English Fathoms.	0	25	50	100	200	300	400	800	Greater Dpths.
$O + N = 100$ O p. ct.	33.7	33.4	32.2	30.2	33.4	11.4	15.5	22.6	23.5

With respect to the absolute amounts of the gases boiled out of the different samples of water, nothing is stated in the work alluded to, but the following Table[2] has since appeared.

Depth in Feet.	CC. O per Litre	Mean Temperature in C. t.	CC. N per Litre N_1.	CC. N per Litre distilled Water, at Temp. t. Bunsen N_2.	$N_2 - N_1$
600	4.24	14.°6	11.26	11.75	0.49
1200	3.59	13. 0	11.71	11.92	0.21
1800	1.67	6. 9	13.00	13.45	0.45
2400	2.41	5. 1	13.10	14.00	0.90
4800	4.06	2. 5	13.82	15.00	1.14
Greater Depths.	—	1. 5	14.37	15.40	1.03

A brief account has now been given of what had previously been accomplished as regards the solution of the problem presented by the air in sea-water.

In the spring of 1876, when fitting out the Norwegian Expedition, which had for its object the investigation, during the summer months of 1876, 1877, and 1878, of

[1] The Voyage of the 'Challenger.' The 'Atlantic.' 2, p. 366.
[2] Ber. Berl. chem. Ges. 11, p. 410.

undersøge det mellem Norge, Færøerne, Island, Jan Mayen og Spitsbergen beliggende Hav, vare heller ikke de paa den engelske Challengerexpedition udførte Observationer offentliggjorte, saaat de Data, der den Gang forelaa, i Righoldighed paa ingen Maade kunde sammenlignes med dem, som nu staa til Raadighed. Især var det med Hensyn paa den geografiske Udbredning, at Observationerne ikke kunde give synderlg omfattende Oplysninger, idet det eneste Hav, som endnu var grundigt undersøgt, nemlig Nordsøen, baade med Hensyn paa Dybde og øvrige physikalske Forholde afveg i høi Grad fra det store Verdenshav, forsaavidt man kjendte det. Da der først var fattet Beslutning, om at der ogsaa paa den norske Nordhavsexpedition skulde udføres chemiske Undersøgelser af samme Art som paa de tidligere Expeditioner, maatte det derfor for Hr. S. Svendsen, hvem disse Arbeider oprindelig vare overdragne, fremstille sig som en meget vigtig, ja man kan sige, som den vigtigste Opgave at tilveiebringe de fornødne Oplysninger om Gasarterne i Søvandet, hvad angaar den Del af Verdenshavet, som Norge havde paataget sig at gjøre til Gjenstand for videnskabelig Undersøgelse. Med Hensyn paa de Midler, der skulde benyttes til Løsningen af denne Opgave, da kunde Valget af disse ikke falde vanskeligt, da de af Dr. Jacobsen benyttede Methoder og Apparater strax maatte udpege sig som de hensigtsmæssigste fremfor Alt, hvad der for Resten stod til Raadighed, selv om ikke Hensynet til Resultaternes Sammenlignelighed havde gjort deres Anvendelse ønskelig. Svendsen besluttede derfor uden Modificationer at optage de paa Pomeraniaexpeditionen benyttede Arbeidsmethoder, og var det i Henseende til Expeditionens Udrustring et stort Held, at Professor Dr. Jacobsen velvilligen tilbød sig at anskaffe de til de chemiske Undersøgelser fornødne Apparater.

Det var dog ikke alle de ved Pomeraniaexpeditionen benyttede Apparater, som ogsaa kom til Anvendelse paa den norske Nordhavsexpedition, idet man der besluttede at anvende en af Capitain Wille construeret Vandhenter, som især i en Henseende maatte være at foretrække for den af Dr. H. A. Meyer angivne. Paa denne maatte nemlig, naar den skulde optage Vandprøver fra intermediære Dyb, Cylinderen udløses ved et langs Linen nedsænket Lod, som aldeles udelukkede Muligheden af paa Linen samtidig at have anbragt Thermometre eller deslige, saaledes som det uden mindste Ulempe kan forenes med Brugen af Willes Vandhenter.

Willes Vandhenter, som findes afbildet i Fig. 2, er af Opfinderen bleven beskrevet paa følgende Maade:

"Vandprøven indesluttes i dette Instrument i et for Pladsens Skyld spiralformig bøiet Rør, der under Nedfiringen i Vandet holdes aabent i begge Ender, saaledes at Vandet frit kan strømme igjennem; men naar Instrumentet ophales et kort Stykke, lukkes Enderne af Røret med to Ventiler, hvorved det da i Røret staaende Vand afstænges og kan bringes op.

the sea lying between Norway, the Feröe Islands, Iceland, Jan Mayen, and Spitzbergen, the results of the observations instituted on the 'Challenger' Expedition had not yet been made public; and hence the data then obtained were few compared to those of which we are now in possession. It was more particularly with respect to geographical distribution, that the information former observations could supply had proved but meagre, inasmuch as the only sea thoroughly investigated, viz the German Ocean, was found to differ widely in regard to depth and other physical conditions from the Atlantic and Pacific, so far at least as our knowledge of both may be said to extend. The resolution once formed, of instituting on the Norwegian North-Atlantic Expedition a series of chemical experiments similar to those performed on former Expeditions, Mr. S. Svendsen, the gentleman on whom the execution of this task was to have devolved, could not but regard as an important, nay the most important, part of his labours, accurate determinations of the gases present in that tract of the Atlantic Ocean which the Norwegian Expedition was to make the subject of scientific investigation. Respecting the means whereby to solve this problem, no difficulty could be experienced in making a choice, since Dr. Jacobsen's methods and apparatus must at once suggest themselves as by far the best, even apart from the consideration, that, for the better comparing of his results with those obtained, their adoption was desirable. Svendsen, therefore, decided in favour of the process — without modification — resorted to on the 'Pomerania' Expedition; and it was a fortunate concurrence, that Professor Jacobsen should kindly volunteer his assistance in procuring the various apparatus necessary for the chemical experiments.

All the apparatus made use of on the 'Pomerania' Expedition, were not, however, adopted on the Norwegian North-Atlantic Expedition; the instrument, for instance, employed to collect water, which, particularly in one respect, must be held preferable to that described by Dr. H. A. Meyer, had been constructed by Captain C. Wille R. N. When drawing water from intermediate depths, the cylinder in the latter is detached by running a weight down the line, which precludes the possibilty of having a thermometer, or any other instrument, attached to it, an advantage which may, without the slightest drawback, be combined with Wille's apparatus.

Wille's instrument for collecting water, of which Fig. 2 is a represention, has been described by the inventor as follows: —

"The samples of water drawn with this instrument are, to save space, brought up in a spiral tube, which, when sunk through the water, is kept open at both ends, to admit of the free passage of the fluid; but, on the instrument, at the required depth, being hauled in a few fathoms, the ends of the tube are closed by means of two valves, and the water it contains, thus prevented from escaping, may be brought to the surface.

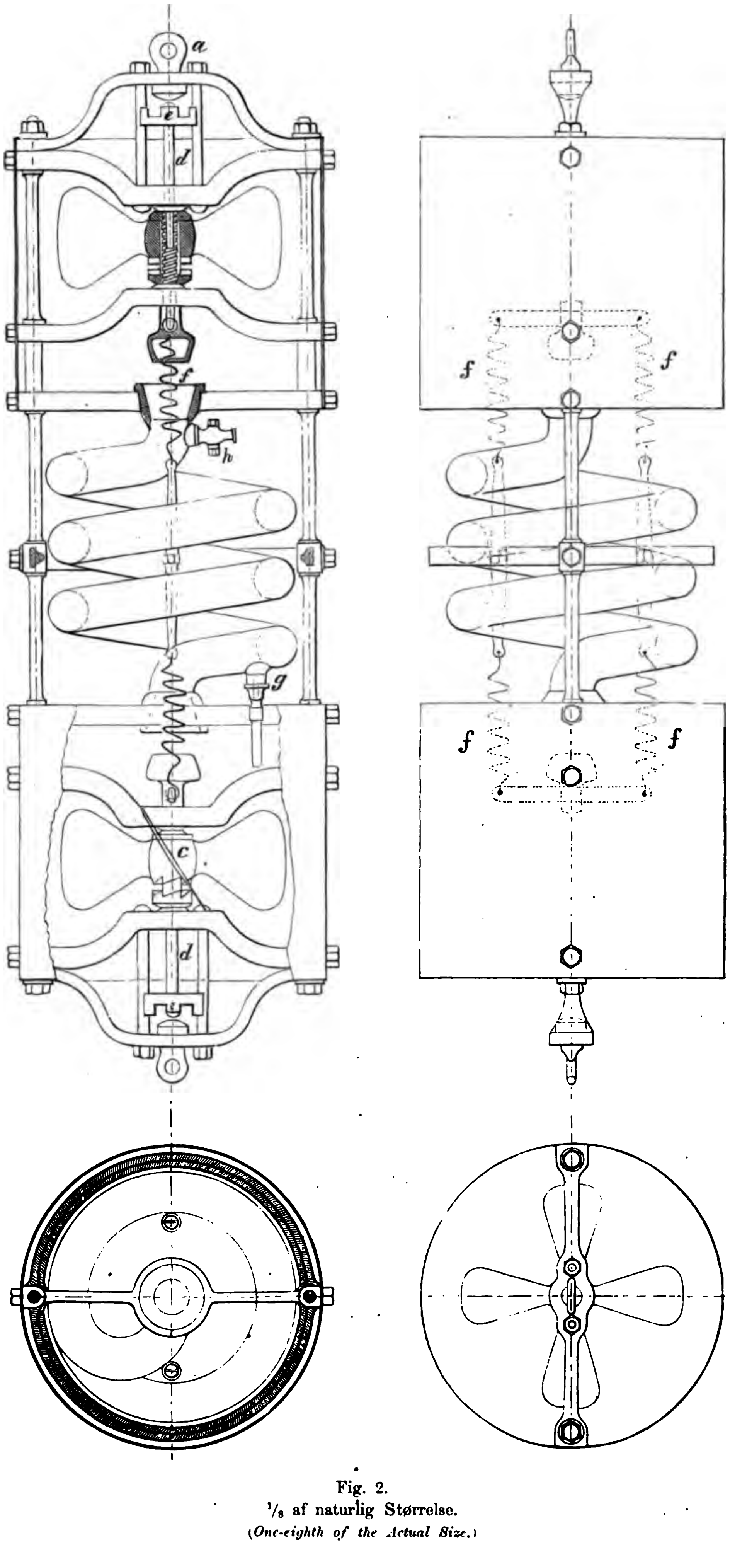


Fig. 2.
$^1/_8$ af naturlig Størrelse.
(One-eighth of the Actual Size.)

Tegningen fremstiller Instrumentet klar til Nedfiring; Tampen af Lodlinen hexes i øverste Øiebolt (*a*) og Loddet i den nedre (*b*). Under Nedfiringen løfter Vandtrykket Propellerne op, saa at Taggerne i Underkant af Propelbosset (*c*) kommer klar af Taggerne i Muffen, gjennem hvilken Ventilstangen (*d*) gaar, og om de ikke kommer ganske klare, sker Propellens Omdreining *med* Skraaplanerne, saa at Muffen og Ventilstangen bliver staaende stille. Naar Instrumentet derimod under Ophalingen bevæges opad, driver Vandtrykket Propellerne ned, de dreies rundt den anden Vei og tager Mufferne med sig. Ventilstængerne, der ikke kan dreie sig rundt, men styres af Tværstykkerne (*e*), skrues da, tilligemed de med Kautschuk overtrukne Ventiler, mod Ventilsæderne i Enderne af Røret, og naar de ere næsten lukkede, glipper den sidste Skruegjænge paa Ventilstangen ud af Skruegjængerne i Muffen, og Spiralfjædrene (*f*) klappe da Ventilerne i, medens Propellerne og Mufferne gaa løse rundt om den glatte Del af Ventilstængerne, og frembyder saaledes meget liden Modstand under Resten af Indhivningen. Instrumentet lukker sig efter omtrent 7 Favnes (13 Meters) Indhaling. Ringen om Midten og Skjærmerne rundt Propellerne beskytte Instrumentet, saaledes at det uden Skade kan ligge paa Bunden.

For at konstatere, om der var Overskud af Luft i de nedre Vandlag, blev der over Svikhullet paaskruet et gjennemboret Laag (*g*), der ved Hjælp af et Stykke Gummislange forenedes til et i den ene Ende lukket Glasrør. Naar Vandet under Nedfiringen strømmede ind i Vandrøret, løb det ogsaa ned i Glasrøret, af hvilket Luften saaledes blev udjaget. Naar Instrumentet kom ombord, endevendtes det, saa at Kranen kom ned og Glasrøret op. Man bevægede nu Vandhenteren lidt frem og tilbage med den øvre Ende, og hvis der havde været Overskud af Luft, maatte denne have arbeidet sig op og vist sig i Toppen af Glasrøret, men dette viste sig stadig fuldt lige til Tops, og blev derfor i den sidste Tid ikke paasat."

Instrumentet kan tømmes gjennem Tappekranen (*h*) og leverer en Vandprøve paa circa 5 Litre.

Udførelsen af de chemiske Arbeider ombord paa den norske Nordhavsexpedition overtoges altsaa først i Følge den oprindelige Plan af Hr. Svendsen, som gjorde Togtet i 1876 med, men blev senere, da denne af Helbredshensyn bad sig fritaget, overdraget Forfatteren, der saaledes har udført de paa de to sidste Togter gjorte Observationer delvis med Assistance af Hr. L. Schmelck, som sidste Sommer medfulgte Expeditionen, og som for Tiden er beskjæftiget med Bearbeidelsen af en anden Del af det paa Expeditionens Togter til chemisk Undersøgelse indsamlede Materiale.

The figure shows the instrument ready for sinking. The end of the sounding-line is made fast to the upper eyebolt (*a*), and the lead to the lower (*b*). On the downward passage, the pressure of the water lifts up the propellers, enabling the cogs in the under surface of the base of the latter (*c*) to get clear of the cogs in the bush, through which passes the rod of the valve (*d*); and if not quite clear, the propeller revolves *with* the inclined planes, the bush and the rod of the valve remaining stationary as before. On the other hand, when the instrument, on being hauled in, is given an upward motion, the pressure of the water forces down the propellers, which then revolve in the opposite direction, carrying along with them the bushes. The rods of the valves, which cannot revolve, being kept in position by transverse pieces (*e*), are, together with the valves covered with caoutschouc, screwed against the ends of the tube. Now, when the latter are almost closed, the last twist of the screw on the rod of the valve slips out of the corresponding twist of the screw on the bush, and the spiral springs (*f*) instantly press down the valves, the propellers and the bushes revolving independently round the smooth portion of the rods, thus presenting but little resistance to the water during the remainder of the upward passage. The instrument closes on being hauled in about 7 fathoms (13 metres). The ring round the middle, and the shields protecting the propellers, prevent the instrument from sustaining injury on its striking the bottom.

With a view to ascertain whether the proportion of air were really greater in the lower strata, a perforated cover (*g*) was screwed over the spigot-hole, and connected by means of a piece of caoutschouc hose with a glass tube, open at one end. Now, when the water on the downward passage flowed into the spiral tube, it also descended into the glass tube, expelling the air. So soon as the instrument came on board, it was inverted, the stop-cock therefore pointing down, and the glass tube up. The upper end of the apparatus being now moved a little backwards and forwards, the surplus of air, if any had been present, must obviously have forced its way upwards, and have appeared, in the form of bubbles, at the top of the tube, which, however, was invariably found to be quite full, and therefore not attached to the apparatus when the fact would no longer admit of doubt."

The stopcock (*h*) serves to empty the instrument, which will hold about 5 litres of water.

The chemical work to be done on board was, as stated above, originally undertaken by Mr. S. Svendsen, who went out on the first cruise, in 1876; but, his health failing, Mr. Svendsen was succeeded by the author, who had therefore to take the observations instituted in 1877 and 1878, partly with the assistance of Mr. L. Schmelck, that gentleman having accompanied the Expedition on the last cruise. (Mr. Schmelck is now engaged in working up other materials collected on the Expedition for chemical investigation).

Da jeg Vaaren 1877 blev opfordret til at overtage disse Arbeider, var der kun givet mig faa Dages Varsel, saaat jeg havde de største Vanskeligheder med at faa udført selv de aller nødtørftigste Forberedelser, og naar det alligevel lykkedes at faa Alt tilfredsstillende ordnet før Afreisen, da skyldes dette udelukkende den Beredvillighed, hvormed Hr. Professor Waage bistod mig blandt Andet ogsaa med Indredningen af det chemiske Laboratorium ombord.

Det paa Expeditionens første Togt i 1876 fremherskende ualmindeligt stormfulde Veir gjorde det i høi Grad vanskeligt ja næsten ugjørligt at udføre de chemiske Observationer ombord, og det Udbytte, som af Svendsen hjembragtes fra første Togt, indskrænkede sig derfor i denne Branche til 17 Luftprøver, hvoraf desuden 3 ved Uheld senere gik tabt. Det rolige Veir, som de to sidste Aar begunstigede Expeditionens Arbeider, tillod mig derimod paa de Togter, hvormed der var givet mig Anledning til at medfølge, at indsmelte et større Antal, idet der for disse Aars Vedkommende erholdtes 80 Luftbestemmelser af de hjembragte Luftprøver, hvoraf 9 vare indsmeltede af Hr. Schmelck. Naar Udbyttet ikke er blevet større, da har dette sin Grund i, at talrige Observationer gik tabt nogle faa ved Uheld under Analysen men de fleste ved Uheld under Indsmeltningen. Saaledes var der til Brug paa sidste Togt fra Küchler & Söhne i Ilmenau sendt mig nogle Luftopsamlingsrør, hvoraf over 75 % tiltrods for den omhyggeligste Behandling sprang enten under Indsmeltningen eller efter samme. Luftprøverne ere alle analyserede ved det af Franckland og Ward[1] angivne Gasanalyseapparat, saaledes at Kulsyren er fjernet med Kalilud og Surstoffet bestemt ved Forbrænding med Vandstof. De 14 førstnævnte Prøver ere analyserede af Hr. Svendsen de øvrige 80 af Forfatteren. De erholdte Resultater findes sammenstillede i Tabel I, hvortil kan bemærkes følgende: De i Tabellen opførte Temperaturangivelser ere mig meddelte af Professor Mohn. Ved Angivelse af de Dybder, hvorfra Vandprøverne ere hentede, er ikke taget Hensyn til, at Vandhenteren først lukker sig efter circa 7 Favnes Indhivning. Ved de med * betegnede 10 Nummere var der i de til Luftprøvernes Opbevarelse benyttede Glasrør smaa Feil, uden at jeg dog har fundet mig foranlediget til at tillægge disse mindre Vægt end de Øvrige, da man vel ikke kan tænke sig Muligheden af en Lækage, uden at den, naar Glasrørene i flere Maaneder opbevaredes under en Trykdifferents mellem det ydre og indre Gastryk af circa 300 til 400^{mm}, maatte have øvet en mærkbar Virkning paa den indesluttede Lufts Sammensætning. Jeg kan saa meget trøstigere tage dem med i Beregningerne, hvor det gjælder at opstille de almindelige Slutninger, som de ikke i synderlig Grad ville bidrage til at forrykke Udseendet af de endelige Resultater. Alle Gasvolumina findes i Tabellen udtrykte i CC. per Litre udkogt Søvand reduceret til 0° og 760^{mm} Barometerstand.

[1] Chem. Soc. Journ. 22—313. 1869.

When, in the spring of 1877, I was requested to undertake these labours, I had but a few days' notice, and experienced, therefore, very great difficulty in making even the most necessary preparations; nor would it indeed have been possible to get everything satisfactorily arranged in so short a time but for the readiness with which Professor Waage came forward to assist me; for instance, in fitting up the chemical laboratory on board.

The exceptionally heavy weather on the first cruise in 1876, rendered it in the highest degree difficult, nay well nigh impracticable, to perform the necessary experiments on board; and hence the chemical work done by Svendsen on the first voyage was, with regard to gas-determinations, confined to collecting 17 samples of air, 3 of which however were subsequently lost. On the two last cruises of the Expedition the weather proved much more favourable, and I succeeded in obtaining a larger number of samples (9 of them collected by Mr. Schmelck), with which, when brought home, 80 air-determinations were performed. A more satisfactory result would, however, have been obtained but for the loss of numerous samples, some few from accident when analysing the gass, but the great majority by reason of the difficulty experienced in sealing. Thus, for instance, on the last voyage 75 per cent of the glass tubes for collecting air, procured from Küchler & Sohne in Ilmenau, notwithstanding the greatest care cracked either during the sealing-process or after its completion. The samples of air were all of them analysed in the apparatus described by Franckland and Ward,[1] the carbonic acid having been absorbed in a lye of potash and the oxygen determined by consuming it with hydrogen. The first 14 samples were analysed by Mr. Svendsen, the remaining 80 by myself. The results obtained will be found in Table I. The temperatures in the Table were given by Professor Mohn. When stating the depths from which the samples of water were drawn, regard has not been had to the fact, that the instrument used for collecting them does not close till it has been hauled in about 7 fathoms. The asterisk marking 10 of the determinations signifies that the glass tubes used for preserving these samples of air had small defects. To these determinations, however, I have not attached less weight than to the others; for it is impossible to conceive that a leakage, after the glass tubes had been exposed for months together to a difference of pressure amounting to 300^{mm}—400^{mm}, viz. that existing between the air inside and the atmosphere without, should not have had an appreciable effect on the composition of the air they contained. Moreover, I hesitate the less to include them as factors when seeking to arrive at general conclusions, since they cannot to any considerable extent disturb the character of the final results. The volumes are given in cubic centimetres per litre of the sea-water examined, reduced to a temperature of 0° and a pressure of 760^{mm}.

[1] Chem. Soc. Journ. 22, p. 313; 1869.

Tabel I.

No.	Stat. No.	Nordlig Bredde. (*North Latitude.*)	Længde fra Greenwich. (*Longitude from Greenwich.*)	Dybde hvorfra Prøven hentet. (*Depth from which the Samples were collected.*) Engelske Favne. (*English Fathoms.*)	Meter. (*Metres.*)	O + N CC. per Litre.	N CC. per Litre.	O + N = 100 O % (*O per cent.*)	Temperatur. Celsius.	Anmærkninger. (*Remarks.*)
1		Husö		0	0	17.4	11.3	35.1	10.5	
2	14	62° 4′	2° 44′.5 E.	226	413	20.1	13.8	31.1	6.1	
3	32	63 10	4 51.3	430	786	19.0	13.0	31.7	—0.6	
4	33	63 5	3 0	0	0	18.9	12.4	34.4	11.8	
5	33	63 5	3 0	525	960	17.3	11.7	32.6	—1.1	
6	35	63 7	1 26 W.	0	0	17.0	11.1	35.0	10.4	
7	35	63 7	1 26	721	1319	18.4	12.4	32.6	—0.9	
8	37	62 28.3	2 29	309	565	18.5	12.4	32.8	0.1	
9	37	62 28.3	2 29	690	1262	18.3	12.3	32.7	—1.1	
10	40	63 22.5	5 29	0	0	17.1	11.1	35.2	9.7	
11	40	63 22.5	5 29	515	942	20.5	13.9	32.4	—0.4	
12	51	65 53	7 18	515	942	20.6	13.9	32.3	—0.6	
13	51	65 53	7 18	1163	2127	20.9	14.1	32.7	—1.1	
14	52	65 47.5	3 7	1861	3403	—	—	32.2	—1.2	
15	95	60 42	4 13.7 E.	175	320	—	—	32.4	5.8	
16	96	66 8.5	3 0	805	1472	—	—	32.3	—1.1	
17	125	67 52.5	5 12	700	1280	20.5	13.7	33.0	—1.1	
18	125	67 52.5	5 12	700	1280	20.0	13.3	33.6	—1.1	
19	152	67 18	12 46	125	229	—	—	31.0	4.1	
20	162	68 23	10 20	795	1454	20.6	13.9	32.6	—1.2	
21	162	68 23	10 20	795	1454	19.4	12.9	33.7	—1.2	Udkogt efter nogen Tids Henstand. (Boiled after the lapse of a short interval.)
22	171	69 18	14 29	642	1174	19.6	13.0	33.5	—1.0	
23	179	69 32	11 10	1607	2939	—	—	32.1	—1.2	
24	183	69 59.5	6 15	0	0	20.2	12.9	36.1	8.6	
25	183	69 59.5	6 15	0	0	—	—	36.1	8.6	
26	184	70 4	9 50	1547	2829	21.5	14.6	32.0	—1.3	
27	184	70 4	9 50	600	1097	20.7	14.1	32.1	0.0	
28	189	69 41	15 42	0	0	18.4	12.0	35.0	9.6	
29	189	69 41	15 42	860	1573	21.5	14.6	32.0	—1.1	
30	200	71 25	15 40.5	620	1134	19.9	12.8	35.8	—1.0	Udkogt efter 5—6 Timers Henstand. (Boiled after the lapse of 5 or 6 hours.)
31		Indløbet til Malangenfjord. (Entrance to the Malangen Fjord.)		0	0	—	—	35.5	8.5?	
32	213	70° 23′	2° 30′	0	0	18.6	12.1	34.9	8.2	
33	213	70 23	2 30	1760	3219	19.6	12.9	34.0	—1.2	
34	213	70 23	2 30	1760	3219	—	—	33.8	—1.2	
35	215	70 53	2 0 W.	0	0	—	—	34.8	8.0	
36	215	70 53	2 0	700	1280	20.1	13.6	22.4	—0.6	
37	215	70 53	2 0	1665	3045	19.2	12.9	32.8	—1.2	
38	226	70 59	7 51	0	0	—	—	33.7	3.0	
39	226	70 59	7 51	340	622	—	—	32.7	—0.6	
40	—	69 20	11 18	0	0	20.7	13.3	35.8	4.3	
41	—	69 20	11 18	0	0	—	—	35.4	4.3	
42	243	68 32.5	6 26	0	0	20.0	13.1	34.7	7.8	
43	243	68 32.5	6 26	600	1097	22.1	15.0	32.2	—0.8	
44	243	68 32.5	6 26	1385	2533	22.6	15.3	32.5	—1.3	
45	247	68 5.5	2 24 E.	0	0	19.3	—	—	9.4	
46	247	68 5.5	2 24	500	914	—	—	32.3	—0.4	
47	249	68 12	6 35	1063	1944	21.4	14.5	32.3	—1.3	
48	252	Søndenfor Skraaven. (South of Skraaven.)		0	0	18.2	11.9	34.7	14.0?	
49	253	Skjærstadfjord. (The Skjærstad Fjord.)		263	481	20.9	13.8	34.2	3.2	
50	254	67° 27′	13° 25′	0	0	18.2	11.9	34.8	10.0	
51	254	67 27	13 25	70	128	21.3	14.2	33.2	4.8	
52	254	67 27	13 25	140	256	19.5	13.2	32.4	5.8	
53	264	70 56	35 37	0	0	20.6	13.3	35.5	5.2	
54	264	70 56	35 37	86	157	20.7	13.8	33.1	1.9	
55	275	74 8	31 12	0	0	20.5	13.3	34.9	2.9	
56	275	74 8	31 12	147	269	21.9	14.6	33.4	—0.4	
57	278	74 1.5	22 27	0	0	20.4	13.3	35.0	4.2	
58	278	74 1.5	22 27	230	421	20.7	13.8	33.3	0.9	

No.	Stat. No.	Nordlig Bredde. (*North Latitude.*)	Længde fra Greenwich. (*Longitude from Greenwich.*)	Dybde hvorfra Prøven hentet. (*Depth from which the Samples were collected.*) Engelske Favne. (*English Fathoms.*)	Meter. (*Metres.*)	O + N CC. per Litre.	N CC. per Litre.	O + N = 100 O % (*O per cent.*)	Temperatur. Celsius.	Anmærkninger. (*Remarks.*)
59	283	73° 47'.5	14° 21'	0	0	19.8	12.8	35.4	7.2	
60	283	73 47.5	14 21	0	0	19.5	12.6	35.3	7.2	
61	286	72 57	14 32	0	0	20.6	13.2	35.8	7.2	
62	286	72 57	14 32	447	817	21.8	14.8	31.9	—0.8	
63*	293	71 7	21 11	95	174	19.6	13.0	33.5	5.1	
64	295	71 59	11 40	0	0	20.2	12.8	36.7	7.0	
65	295	71 55	11 30	600	1097	21.4	14.6	31.7	—0.8	
66	295	71 59	11 40	1110	2030	21.5	14.6	32.1	—1.3	
67	296	72 15.5	8 9	100	183	20.4	13.4	34.2	3.1	
68	297	72 36.5	5 12	1280	2341	21.3	13.8	35.1	—1.4	
69*	301	74 1	1 20 W.	0	0	21.9	14.1	35.6	2.2	
70*	303	75 12	3 2 E.	150	274	22.0	14.7	33.1	—1.1	
71*	304	75 3	4 51	300	549	21.7	14.7	32.2	—0.8	
72	304	75 3	4 51	1735	3173	21.6	14.6	32.2	—1.5	
73*	321	74 56.5	19 30	0	0	23.8	15.4	35.2	0.5	
74	321	74 56.5	19 30	25	46	23.7	15.3	35.4	0.2	
75	323	72 53.5	21 51	0	0	19.3	12.3	36.5	7.8	
76	323	72 53.5	21 51	0	0	—	—	35.8	7.8	
77	332	75 56	11 36	1149	2101	21.9	14.8	32.2	—1.5	
78	332	75 56	11 36	1149	2101	22.0	15.0	31.8	—1.5	
79	335	76 16.5	14 39	0	0	20.8	13.3	36.2	5.4	
80	335	76 16.5	14 39	179	327	21.0	14.0	33.1	1.0	
81	339	76 30	15 39	37	68	21.6	14.2	34.1	0.9	
82	342	76 33	13 18	0	0	21.8	14.1	35.3	6.2	
83	342	76 33	13 18	523	956	20.8	13.8	33.8	—1.0	
84	345	76 42.5	10 9	300	549	20.9	13.7	34.4	1.0	
85	345	76 42.5	10 9	300	549	21.5	14.2	33.9	1.0	
86	347	76 40.5	7 47	0	0	20.9	13.4	35.7	4.4	
87	347	76 40.5	7 47	1429	2613	21.4	13.9	35.1	—1.3	
88*	349	76 30	2 57	1487	2719	21.7	14.6	32.5	—1.5	
89	350	76 26	0 29 W.	300	549	21.9	14.7	32.7	—1.1	
90	350	76 26	0 29	1686	3083	22.9	15.3	33.3	—1.5	
91*	352	77 56	3 29 E.	300	549	21.9	14.8	32.5	—0.8	
92*	352	77 56	3 29	1686	3083	22.4	15.1	32.8	—1.5	
93*	359	78 2	9 25	0	0	—	—	35.7	4.3	
94*	362	79 59	5 40	0	0	20.3	13.0	35.8	5.2	

Vandprøverne ere overalt, hvor det Modsatte ikke udtrykkelig er anført, udkogte strax efter deres Optagelse.

Som man ser, ligner denne Tabel overmaade meget den af Dr. Jacobsen opstillede, hvad man ogsaa paa Forhaand kunde vente, da de undersøgte Districter fuldstændig gaa over i hinanden, og naar Differentserne mellem de af Hr. Svendsen og mig opførte Tal ere noget større, da kommer dette ligefrem af det af os bearbeidede Felts større Udstrækning og deraf følgende større Uensartethed i de physikalske Forholde.

Hvad der er mest iøinefaldende, er det paafaldende Phænomen, at der med Hensyn paa den relative Sammensætning af den i Overfladevandet indeholdte Luft paa den norske Nordhavsexpedition er fundet betydeligt større Surstofgehalt end af Dr. Jacobsen for Nordsøen opstillet, saaledes er Surstofprocenten i Overfladen i Nordsøen bestemt til i Middel 33.93 % af den samlede Luftmængde, medens den for det af den norske Expedition i 1876 og 77 undersøgte Strøg søndenfor den 70de Breddegrad, beløber sig

The samples of water were all, except when the reverse is stated, boiled immediately on being drawn.

As will be seen, this Table agrees very closely with that prepared by Dr. Jacobsen, which was indeed to be expected, since the tracts investigated coalesce; and the somewhat greater differences exhibited by Mr. Svendsen's and my own figures arise simply from the region explored by the Expedition having been more extensive, involving greater dissimilarity in the physical conditions.

With regard to the relative composition of the air in surface-water, the proportion of oxygen was, strange to say, on the Norwegian North-Atlantic Expedition found to be considerably greater than that given by Dr. Jacobsen for the North Sea. The mean proportion of oxygen in the surface-water of the North Sea he determined to be 33.93 per cent of the total amount of air, whereas the mean proportion for the tract of the North-Atlantic stretching south of the 70th parallel of latitude, that investigated by the

til i Middel 34.96 og for det i 1878 undersøgte mellem 70de og 80de Breddegrad beliggende Strøg til 35.64 %. Fuldstændigt tilsvarende er det af Buchanan fundet at være paa den sydlige Halvkugle, idet Surstofprocenten i Overfladen der varierer fra omkring 33 i Æqvatoregnene til ca. 35 omkring den sydlige Polarcirkel.

Dette lod med temmelig stor Bestemthed formode, at de for destilleret Vand gjældende, af Bunsen opstillede, Absorbtionscoefficienter ikke skulde være gyldige for Søvand, idet det, naar Overfladevandsluftens Sammensætning fandtes at variere med Bredden, maatte være det Naturligste at skrive disse Variationer paa Temperaturforandringerne. Det vil imidlertid ikke føre til noget rimeligt Resultat, om man vil betragte Temperaturen som den Variable og af de her foreliggende Observationer forsøge at udlede en Lov for Absorbtionscoefficienternes Variationer med Temperaturen. Man vil da finde, at de enkelte Observationer staa ikke ubetydeligt i Strid med hinanden, idet der for Surstofmængdernes Vedkommende overalt optræder meget større Afvigelser, end man kan antage begrundede i Observationsfeil. Det kunde dog ikke synes tilraadeligt at lade det bero hermed og forsøge at discutere de foreliggende Observationer uden nøiere Kjendskab til Absorbtionscoefficienternes Afhængighed af Temperaturen, og jeg besluttede derfor at bestemme saavel Sammensætning som Mængde af den i Søvandet ved forskjellige Temperaturer opløste Luft.

Først gjordes en Del Forsøg, hvorved Søvandet i et Bad af constant Temperatur søgtes mættet ved flere Timers Gjennemledning af Luft, (saaledes som Bunsen har gaaet frem ved sine Bestemmelser[1]), hvorefter den opløste Luft uddreves og analyseredes paa den før beskrevne Maade. De paa denne Maade mættede Vandprøver afgave bestandig Luftmængder, som uden Hensyn til den Temperatur, hvorved Vandet var mættet, viste nogenlunde nær den samme Sammensætning (med 34.9 % Surstof mod 65.1 % Kvælstof), medens de ofte temmelig stærkt afvigende Tal, som udtrykte de absolute Mængder af opløste Gaser, tydeligt viste, at der paa denne Maade ikke var opnaaet fuldstændig Mætning.

Professor Waage foreslog mig derfor at gjentage disse Forsøg med nogen Variation i den Maade, hvorpaa Mætningen iværksattes, og har jeg som Følge deraf ved de senere Forsøg benyttet følgende Fremgangsmaade. En passende Portion Søvand af nogenlunde høi Egenvægt rystedes med Luft i en rummelig Kolbe i et Tidsrum fra 1 til 2 Timer under stadig Vexlen af den i Kolben værende Luft og hensattes derpaa i nogle Timer ganske rolig, idet Temperaturen saavel under Rystningen som senere holdtes fuldstændig constant. Forat overbevise mig om, at jeg har opnaaet fuldstændig Mætning, har jeg nærmet mig Mæt-

[1] Bunsen, Gasom. Methoden — 165.

Norwegian Expedition in 1876 and 1877, amounts to 34.96, and for that lying between the 70th and 80th parallels of latitude, to 35.64 per cent. Buchanan observed precisely the same phenomenon in the southern hemisphere, the proportion of oxygen varying from about 33 per cent in the Equatorial Seas to about 35 per cent in the vicinity of the Antarctic Circle.

Reasoning on these data, there were strong grounds to assume, that the coefficients of absorption given by Bunsen for distilled water could not apply to sea-water; for, the composition of the air in surface-water having been found to vary with the latitude, the most probable cause of this phenomenon would seem to be temperature. Meanwhile, we shall not arrive at a satisfactory result by regarding temperature as the variable factor, and by seeking from the observations here set forth to discover a law according to which the coefficients of absorption vary with the temperature. The individual observations would in that case be found to clash, inasmuch as the variation with regard to oxygen is invariably greater than can be assumed to arise from errors of observation. However, it did not seem advisable to leave the question as it stood, and proceed to the discussion of the results without having further investigated the relation of the coefficients of absorption to the temperature; and I resolved, therefore, on determining alike the composition and the amount of the air absorbed by sea-water at different temperatures.

A series of experiments were first instituted with a view to saturate sea-water with air, viz. by placing it in a bath of constant temperature, and for the space of several hours uninterruptedly conducting through it a current of air, — the mode of operation adopted by Bunsen for his determinations,[1] — after which the air absorbed in the water was driven off, and analysed by the process previously described. The samples of water saturated in this manner invariably yielded quantities of air which, irrespective of the temperature at which the water had been saturated, were found to be very nearly uniform in composition, viz. 34.9 per cent oxygen and 65.1 per cent nitrogen, whereas the figures, often widely divergent, expressing the absolute quantities of the gaseous bodies absorbed, gave sufficient proof that by this method complete saturation had not been attained.

At Professor Waage's suggestion, I repeated these experiments, varying slightly the means by which saturation was sought to be effected, and have since adopted the following mode of operation. A quantity of sea-water, of considerable specific gravity, is shaken, along with air, in a roomy matrass for one or two hours, the air in the matrass being frequently renewed, and then left perfectly still for a few hours, at the precise temperature preserved during its continual agitation. To be quite sure that I have really succeeded in saturating the water, I approach the point of saturation as it were from opposite directions:

[1] Bunsen, Gasom. Methoden, p. 165.

ningspunctet fra begge Sider, idet jeg paa den ene Side har behandlet Vand, som paa Forhaand var utilstrækkeligt mættet med Luft ved vedkommende Temperatur, og paa den anden Side først har mættet Vandet ved en betydelig lavere Temperatur for derefter, som ovenfor beskrevet, at ryste det med Luft ved den Temperatur, hvorved det ønskedes mættet. Den Barometerstand, hvorved Vandprøverne ere mættede, er altid bleven observeret, og ere de uddrevne Gasmængder reducerede til Mætning ved 760^{mm}, idet de absorberede Volumina ere satte proportionale med Trykket. Resultaterne ere sammenstillede i nedenstaaende Tabel, hvor Gasmængderne ere udtrykte som CC. pr. Litre udkogt Vand reduceret til 0° og 760^{mm} Tryk. De med fede Typer trykkede Tal hidrøre fra de Vandprøver, der i Forveien have været mættede med Luft ved en lavere Temperatur. Ved de med Klammer sammenføiede Tal ere begge Luftprøver udkogte af samme Vandprøve.

0° C.		5° C.		10° C.		15° C.	
O	*N*	*O*	*N*	*O*	*N*	*O*	*N*
7.76	14.36	6.83	13.20	6.31	12.14	5.60	10.79
7.85	14.56	6.90	13.30	**6.30**	**12.06**	5.79	11.20
7.71	14.31	**6.97**	**13.16**	**6.25**	**12.04**	**5.70**	**11.04**
—	—	**7.01**	**13.20**	—	—	—	—

Som Middelværdier erholder man heraf:

° C.	0	5	10	15
O	7.77	6.93	6.29	5.70
N	14.41	13.22	12.08	11.01
$O + N = 100$ *O* %	35.03	34.39	34.24	34.11

Til yderligere Control paa Rigtigheden af denne Tabel hensattes en Vandprøve i uproppet Kolbe ved 0° i 7 Døgn, hvorpaa den deri opløste Luft udkogtes og analyseredes, og viste den uddrevne Gas sig at være omtrentlig af samme Sammensætning som ovenfor angivet nemlig 35.18 % *O* mod 64.82 % *N*. Af den samlede Luftmængde erholdtes her ingen Maaling, da desværre en liden Blære under Overfyldningen i Evdiometret gik tabt, den resterende Del maalte 21.71 CC. Som man af denne Tabel vil kunne se, er den Kvælstofmængde, som 1 Litre Søvand absorberer af den atmosphæriske Luft, ligetil proportional med Temperaturen og lader sig udtrykt i CC. meget nøie fremstille ved Formelen

$$N = 14.4 - 0.23\,t,$$

hvoraf man istedetfor de

observerede Værdier .	14.41	13.22	12.08	11.01
kan beregne	14.40	13.25	12.10	10.95.

Hvad angaar den absorberede Surstofmængde, da er Forholdet ikke længere saa simpelt, idet den Curve, der betegner Variationen med Temperaturen, ikke længere er en ret men en svagt krummet Linie, som paa Strøget fra 0 til 10°, hvorom der her nærmest er Tale, lader sig udtrykke ved Formelen

on the one hand, operating with water that has been imperfectly saturated at a given temperature, and on the other, saturating that water at a much lower temperature; and not till then proceeding to shake it along with air at the temperature for which saturation is sought to be attained. The atmospheric pressure at which the samples of water were saturated, was always noted down, and the quantity of gas driven off reduced to the point of saturation at 760^{mm}, the volumes absorbed being put proportional with the pressure. The results are set forth in the following Table, the amounts of gas being expressed in cubic centimetres per litre of the water examined, reduced to a temperature of 0° and a pressure of 760^{mm}. The figures printed in thick type refer to samples of water previously saturated with air at a lower temperature; those in brackets are determinations performed with the same sample of water.

0° C.		5° C.		10° C.		15° C.	
O	*N*	*O*	*N*	*O*	*N*	*O*	*N*
7.76	14.36	6.83	13.20	6.31	12.14	5.60	10.79
7.85	14.56	6.90	13.30	**6.30**	**12.06**	5.79	11.20
7.71	14.31	**6.97**	**13.16**	**6.25**	**12.04**	**5.70**	**11.04**
—	—	**7.01**	**13.20**	—	—	—	—

The mean proportions are accordingly: —

C.	0°	5°	10°	15°
O	7.77	6.93	6.29	5.70
N	14.41	13.22	12.08	11.01
$O + N = 100$ *O* p.ct.	35.03	34.39	34.24	34.11

With the object of testing still further the accuracy of this Table, a sample of water was allowed to stand over in an open matrass at a temperature of 0° for the space of 7 days, when the air absorbed by it was boiled out and analysed; but the composition of the gas driven off proved to be almost the same as that specified above, viz. 35.18 per cent oxygen and 64.82 per cent nitrogen. Of the total amount of air no measurement was obtained, a small bubble of gas having unfortunately escaped when transferring the air into the eudiometer; the remaining portion measured 21.71^{cc}. As appears from this Table, the quantity of nitrogen absorbed from the atmosphere by 1 litre of sea-water is strictly proportional to the temperature, and may be very accurately expressed in cubic centimetres by the formula —

$$N = 14.4 - 0.23\,t,$$

which, in place of

the values observed.	14.41	13.22	12.08	11.01
gives	14.40	13.25	12.10	10.95

With regard to the amount of oxygen absorbed, the proportion is less easily expressed, since the curve indicating the variation with the temperature will no longer be a straight, but a slightly curved line, which, from 0° to 10°, the interval most important here, may be expressed by the formula —

$$O = 7.79 - 0.2\,t + 0.005\,t^2.$$

som istedetfor de observerede Værdier	7.77	6.93	6.29
giver	7.79	6.92	6.29

Men Hensyn paa den relative Sammensætning af den absorberede Luft da er den ikke, saaledes som af Bunsen for destilleret Vand fundet, uafhængig af Temperaturen men varierer med denne, saaledes at Surstofprocenten paa Strøget fra 0° til 15° forandrer sig med en hel Procent.

Betragter man Resultaterne af disse Forsøg som Norm, viser det sig, at den relativt til den samlede Luftmængde meget høie Surstofgehalt, som er observeret i Overfladen i den nordlige Halvdel af det undersøgte Hav, i Virkeligheden skriver sig fra en Overmætning med Surstof og ikke, som man ogsaa kunde tænkt, fra en mangelfuld Mætning med Kvælstof, idet der mærkeligt nok her findes en Surstofgehalt, der meget hyppigt overskrider den af disse Forsøg beregnede med 0.5 CC. og derover. Det vil sige, der optræder saa store Afvigelser, at de paa ingen Maade kunne tilskrives Observationsfeil, og det viser sig saaledes, at Surstofgehalten i Overfladen ikke alene afhænger af Tryk og Temperatur, men rimeligvis ogsaa maa paavirkes af en eller flere andre ubekjendte Aarsager.

Naar det gjælder nærmere at studere Surstofmængdens Variation med Dybden, falder det bekvemmest at udtrykke den som Procenter af den samlede Luftmængde, da den absolute Luftmængde varierer i meget stærkere Grad med Temperaturen end Luftens relative Sammensætning, og man vil saaledes ved at benytte denne Udtryksmaade opnaa at gjøre sig i betydeligt større Udstrækning uafhængig af Temperaturens Indflydelse.

Ordner man de paa denne Maade udtrykte Tal efter Dybden, viser det sig, at der med Hensyn paa Surstofprocentens Størrelse i de forskjellige Dyb existerer en temmelig udpræget Lovmæssighed, som nærmere kan karakteriseres af nedenstaaende Tabel, der er uddraget af samtlige Observationer, naar undtages de to, hvor Udkogningen ikke foretoges strax men først efter nogen Tids Henstand.

Dybdeintervaller.		Antal Observationer.	Midlere Dybde.		Midlere Surstofprocent.
Engelske Favne.	Meter.		Engelske Favne.	Meter.	
0	0	28	0	0	35.31
0—100	0—183	6	69	126	33.93
100—300	183—549	14	210	384	32.84
300—600	549—1097	16	420	768	32.50
600—1000	1097—1829	11	684	1251	32.58
1000—1400	1829—2560	6	1192	2180	32.78
1400—1760	2560—3219	10	1646	3010	32.89

De enkelte Observationers Afvigelser fra den ved denne Tabel bestemte Regel ere i Betragtning af det undersøgte Felts store Udstrækning hverken mange eller synderlig store, idet kun 10, No. 2, 19, 38, 49, 64, 68, 83,

$$O = 7.79 - 0.2\,t + 0.005\,t^2,$$

giving	7.79	6.92	6.29
in place of the values observed.	7.77	6.93	6.29

Hence, the relative composition of the air absorbed is not, as Bunsen found to be the case with distilled water, independent of temperature, but varies with that factor, the percentage of oxygen, for instance, differing as much as 1 per cent between 0° and 15°.

Now, assuming the results of these experiments to furnish a normal standard, the relatively large proportion of oxygen as compared with the total amount of air present in the surface-water of the northern tracts of the sea investigated, will be found to arise from supersaturation with oxygen, and not, as might be supposed, from imperfect saturation with nitrogen, seeing that the proportion of oxygen exceeded that computed from these experiments by as much as, or even more than, 0.5^{cc}; for a difference so considerable does not admit of being ascribed to errors of observation. On the basis of these facts, the proportion of oxygen in surface-water is shown to depend not only on pressure and temperature, but, probably, also on the effect of one or more causes as yet unknown.

When investigating the degree in which the proportion of oxygen varies with the depth, it will be most convenient to express the difference as a percentage of the total amount of air, the absolute amount of air varying to a much greater extent with the temperature than does its relative composition; besides, with this mode of expression considerably less regard need be had to the influence of temperature.

If the figures representing the results thus expressed are arranged according to depth, the proportion of oxygen present in the different strata will be found to exhibit very considerable uniformity, as appears from the following Table, based as it is on the whole series of determinations, with the exception of two, the water with which the latter were performed not having been boiled at once, but allowed to stand over for some time previous to examination.

Intervals of Depth.		Number of Observations.	Mean Depth.		Mean Percentage of Oxygen.
English Fathoms.	Metres.		English Fathoms.	Metres.	
0	0	28	0	0	35.31
0—100	0—183	6	69	126	33.93
100—300	183—549	14	210	384	32.84
300—600	549—1097	16	420	768	32.50
600—1000	1097—1829	11	684	1251	32.58
1000—1400	1829—2560	6	1192	2180	32.78
1400—1760	2650—3219	10	1646	3010	32.89

Considering the great extent of the region investigated, the deviation of the individual observations from the standard given in this Table is neither frequent nor considerable, 10 only, viz. Nos. 2, 19, 38, 49, 64, 68, 83, 84,

84, 85 og 87, fjerne sig om mere end 1 Procent fra det almindelige Resultat, medens man af samtlige Observationer kan bestemme en enkelt Observations sandsynlige Afvigelse fra den efter denne Tabel optrukne Curve til ± 0.52 %, en Afvigelse saa liden, at en ikke ringe Del af den kan skrives paa Observationsfeil.

De største Uoverensstemmelser optræde talrigst i et Dyb fra 300—600 Favne (549—1097 Meter) men findes ogsaa enkeltvis i større Dyb.

Fra Bunden hidrører i de større Dyb kun to Luftprøver med væsentlig for høi Surstofprocent nemlig No. 68 og 87, optagne fra to Puncter, som mærkeligt nok begge ligge paa en Linie paralel med og tæt ved Grændsen mellem den nordover strygende varme Strøm og den sydover forbi Jan Mayen gaaende Polarstrøm. Bortser man imidlertid fra disse de væsentligste Uoverensstemmelser, som bidrage til at give Curven et om end meget svagt Minimum i 300—400 Favnes (549—732 Meters) Dyb, vil man i Korthed kunne udtale Regelen for Surstofprocentens Aftagen med Dybet saaledes: Surstofprocenten er i Overfladen gjennemsnitlig 35.3 og aftager derpaa først hurtigt senere langsommere til henimod 32.5 i 300 Favnes (549 Meters) Dyb, hvorfra den med stigende Dyb holder sig paa det Nærmeste constant. Det kan bemærkes, at af de her undersøgte Vandprøver 40 ere øste lige ved Havbunden. Man vil imidlertid forgjæves bestræbe sig for at opdage nogen Forskjellighed i Egenskaber mellem disse og de fra ligestore intermediære Dyb optagne.

Hvor det gjælder at studere Variationerne af den absolute Luftmængde, maa det synes naturligt som Maal for denne at benytte den opløste Kvælstof, idet den observerede Luftmængde paa Grund af det vedvarende Forbrug af Surstof i de dybere liggende Lag bestandig kan forudsættes at være mere eller mindre forskjellig fra den Mængde, som vilde absorberes i Overfladen under directe Paavirkning af Atmosphæren. Kvælstofmængden kan derimod paa Grund af denne Gasarts stærkt udprægede Indifferentisme ligeoverfor andre Legemer uden synderlig Feil antages uafhængig af locale Tilfældigheder.

Anvendes saaledes Kvælstofmængden som Maal for den i Søvandet opløste Luft, viser der sig i Fordelingen ogsaa her en udpræget Lovmæssighed, naar undtages, at der i de af Svendsen paa det første Togt udførte Observationer overalt er fundet en mindre Kvælstofmængde, end man efter alle øvrige foreliggende Observationer skulde vente. Bortser man imidlertid fra disse paa første Togt udførte 14 Observationer, vil man se, at alle de Øvrige paa faa Undtagelser nær meget vel stemme overens med de Tal, man kan beregne efter den ved de ovenciterede Forsøg bestemte Formel

$$N = 14.4 - 0.23\,t.$$

85, and 87 exhibiting a difference of more than 1 per cent as compared with the general result, whereas the probable deviation of a single observation from the curve drawn according to this Table may be computed at ± 0.52 per cent, a deviation so small as to arise, probably, in no slight degree from errors of observation.

The greatest discrepancies refer chiefly to a depth of 300—600 fathoms (549—1097 metres); now and again, however, they were met with in water obtained from greater depths.

In only two of the samples of air expelled from bottom-water drawn where the depth was great, did the percentage of oxygen prove much too high, viz. in Nos. 68 and 87, the samples of water yielding them having been obtained from two spots which, strange to say, are in a line running parallel and in close proximity to the boundary between the warm current flowing north and the cold Arctic current flowing south past the Island of Jan Mayen. Now, if we exclude from these differences the chief of those that contribute towards giving the curve a very slight but appreciable minimum at a depth of from 300 to 400 fathoms (549—732 metres), the rule according to which the proportion of oxygen is found to diminish with the depth may be expressed as follows: — The proportion of oxygen, which at the surface is 35.3 per cent, begins at once and continues to diminish, at first rapidly and afterwards at a slower rate, till it has reached 32.5 per cent, at the depth of 300 fathoms (549 metres), from whence it keeps almost constant. I will not omit to observe, that of the samples of water examined 40 had been drawn from the bottom; is was, however, impossible to detect any difference in composition between these and the samples obtained from equal intermediate depths.

When investigating the variation in the absolute amount of air, it will obviously be advisable to make use of the nitrogen absorbed, since the quantity of air observed in the deeper strata may, by reason of the steady consumption of oxygen, be assumed to differ more or less from that which would be absorbed at the surface under the direct influence of the atmosphere, whereas nitrogen, from the very slight affinity evinced by that gas for other bodies, may, without involving appreciable error, be regarded as proof against the accidents of locality.

If, therefore, the amount of nitrogen be adopted as the standard of measurement for the air absorbed in sea-water, a marked uniformity will here, too, be found to characterise the distribution, as determined by the observations described, with the exception however of Svendsen's, on the first voyage, by which the amount of nitrogen was found to be less than all subsequently instituted observations gave reason to expect. Excluding, then, the 14 observations from the first voyage, all of the others, with but few exceptions, agree closely with the figures which may be found by the formula stated above —

$$N = 14.4 - 0.23\,t,$$

Man faar nemlig af Observationerne følgende Middelværdier:

Dybdeintervaller. Engelske Favne.	Meter.	Middeltemp. °C.	Midlere Kvælstofmængde observeret	Kvælstofmængde beregnet.	Differents.
0	0	6.4	13.07	12.93	—0.14
0—100	0—183	2.7	13.98	13.78	—0.20
100—300	183—549	1.0	14.15	14.17	0.02
300—600	549—1097	—0.6	14.54	14.54	0.00
600—1000	1097—1829	—0.8	14.04	14.58	0.54
1000—1760	1829—3219	—1.4	14.38	14.72	0.34

Naar den midlere Kvælstofmængde her i de dybere Lag er funden noget lavere end man skulde vente, da har dette sin Grund i, at der ved de 5 Observationer No. 17, 22, 33, 36 og 37, alle hidrørende fra Vandprøver fra det i 1877 undersøgte Strøg, er fundet en ca. 1.5 CC. lavere Gehalt, end de ved sin Temperatur vilde kunne optage ved almindeligt Atmosphæretryk. Forresten vil efter alle de øvrige Observationer at dømme ogsaa i de større Dyb Kvælstofmængden findes at stemme overens med den af Formelen beregnede.

En lignende Sammenligning[1] er af Buchanan gjort mellem de af ham for de sydlige Have fundne Tal og de af Bunsen for destilleret Vand opstillede. Der optræder ved denne Sammenligning især ved de lavere Temperaturer ikke ubetydelige Differentser paa lige op til over 1 CC. pr. Litre, men disse vil ved Sammenligning med de efter Forfatterens Formel beregnede Tal saa godt som bortfalde, idet man faar:

Dybde i Fod.	Midlere Temperatur. °C.	Kvælstofmængde efter Buchanan.	Kvælstofmængde efter Formelen.	Differents.
600	14.6	11.26	11.04	—0.22
1200	13.0	11.71	11.41	—0.30
1800	6.9	13.00	12.81	—0.19
2400	5.1	13.10	13.23	0.13
4800	2.5	13.82	13.82	0.00
derover	1.5	14.37	14.05	—0.32

Det fremgaar heraf, at Kvælstofmængden, saaledes som det allerede af Dr. Jacobsen og Andre er antaget, ikke i mindste Maade retter sig efter de i de store Dyb herskende Tryk men kun afhænger af Temperaturen. Den eneste rimelige Fortolkning udelukker Muligheden for, at Tryk- og Temperaturdifferentser i de under Overfladen

[1] Ber. Berl. chem. Ges. — 11 — 410.

as will be seen from the following Table showing the mean values.

Intervals of Depth. English Fathoms.	Metres.	Mean Temp. °C.	Mean Amount of Nitr. observed.	Amount of Nitrogen computed.	Difference.
0	0	6.4	13.07	12.93	—0.14
0—100	0—183	2.7	13.98	13.78	—0.20
100—300	183—549	1.0	14.15	14.17	0 02
300—600	549—1097	—0.6	14.54	14.54	0.00
600—1000	1097—1829	—0.8	14.04	14.58	0.54
1000—1760	1829—3219	—1.4	14.38	14.72	0.34

The mean quantity of nitrogen in the deeper strata proved, accordingly, somewhat lower than there was reason to expect; but this arose from the proportion determined by 5 of the observations, viz. Nos. 17, 22, 33, 36, and 37 — all of them referring to samples of water obtained from the tract of ocean investigated in 1877 — having been about 1.5[cc] less than could be absorbed at the same temperature under ordinary atmospheric pressure. For the rest, judging from all the other observations, the proportion of nitrogen observed, even at greater depths, will be found to agree with that computed by the formula.

A similar comparison[1] was instituted by Buchanan between his results for the water of the Southern Seas and the figures found by Bunsen for distilled water. The differences resulting from this comparison, more especially for a low temperature, are considerable, the greatest reaching 1[cc] per litre; but, on comparing them with the figures given by the author's formula, they will be found almost to vanish, as appears from the following Table.

Depth in Feet.	Mean Temperature. °C.	Amount of Nitrogen accord. to Buchanan.	Amount of Nitrogen comp. by the Formula.	Difference.
600	14.6	11.26	11.04	—0.22
1200	13.0	11.71	11.41	—0.30
1800	6.9	13.00	12.81	—0.19
2400	5.1	13.10	13.23	0.13
4800	2.5	13.82	13.82	0.00
Greater Depths.	1.5	14.37	14.05	—0.32

Hence the amount of nitrogen, as previously assumed by Dr. Jacobsen and others, can in no wise be affected by the increase of pressure at great depths, but must obviously be dependent on temperature alone. The results of these observations exclude, therefore, the possibility of differences in temperature and pressure at depths below

[1] Ber. Berl. chem. Ges. 11, p. 410.

liggende Lag skulde kunne hidføre en anden Fordeling af Luften end den, der allerede existerer fra den Tid, da Vandet sidste Gang befandt sig i Overfladen udsat for fri Paavirkning af Atmosphæren. Luften vil saaledes kun gjennem Vandets Circulation kunne naa ned i Dybet, og nogen Udjevning af Luftmængderne vil der kun kunne ske gjennem Blanding af de forskjelligartede Vandmængder, en Blanding, som under Forudsætning af at der ikke ogsaa foregaar Opvarmning eller Afkjøling, ikke vil kunne forrykke det rette Forhold mellem Temperatur og Kvælstofmængde, da Kvælstofmængdens Variation med Temperaturen fremstilles ved en ret Linie.

Man vil altsaa, dersom disse Forudsætninger holde Stik, ved en Kvælstofbestemmelse i de dybere liggende Vandlag kunne om end meget raat bestemme, om disse have været Gjenstand for en væsentlig Opvarmning eller Afkjøling, siden de sidst befandt sig i Overfladen, forudsat at man kan negligere Virkningerne af Atmosphæretrykkets Forandringer og andre mulige Tilfældigheder, som under Absorbtionen i Overfladen vil kunne gjøre sin Indflydelse gjældende.

Grupperer man de her offentliggjorte Observationer efter Vandprøvernes Temperatur, viser det sig, at Kvælstofmængden meget nøie svarer til den efter denne Temperatur af Formelen beregnede, det vil sige, Vandprøvernes Temperatur skulde ikke i væsentlig Grad have forandret sig, siden de sidst befandt sig i Overfladen. Man faar nemlig:

Temperatur-interval.	Midlere Temperatur.	Midlere Kvælstofmængde.	Beregnet Kvælstofmængde.	Differents.
under 0°	—1°.1	14.32	14.65	0.33
0—3	1.2	14.19	14.12	—0.07
3—6	4.6	13.38	13.34	—0.04
6—9	7.5	12.90	12.67	—0.13
over 9	11.2	11.93	11.82	—0.11

At Overensstemmelsen for Temperaturerne under 0° ikke er saa fuldstændig som ellers, skyldes ogsaa her de ovenfor nævnte 5 Observationer alle udførte paa Togtet i 1877. Beregner man derimod den midlere Temperatur og Kvælstofmængde for dette Interval af de paa sidste Aars Togt gjorte Observationer, erholder man til Middeltemperaturen —1.2 Kvælstofmængden 14.59 CC, altsaa kun 0.09 CC. mindre end beregnet.

Benyttes paa samme Maade de af Dr. Jacobsen offentligjorte Observationer til et Overslag over Kvælstofmængden i Nordsøen, erholder man med runde Tal:

the surface causing a distribution of the air different to that which existed when the water was last at the surface, in direct contact with the atmosphere. Hence the air cannot penetrate to such depths save by the circulation of the water, and an adjustment of the amounts of air can be effected solely by the mixing of the water different in composition, which will not, however, unless we assume a simultaneous increase or decrease of heat, disturb the true relation between the temperature and the amount of nitrogen, since the variation of the latter with the temperature is expressed by a right line.

If, then, these assumptions are found to hold good, it will be possible, when computing the proportion of nitrogen in the lower strata of the water, to determine — very roughly indeed — whether the latter have experienced any increase or decrease of heat since they were last at the surface, provided we can ignore the effect of change in the atmospheric pressure and of other accidental circumstances, which, during the process of absorption, may have made their influence felt.

On grouping together according to the temperature of the samples of water examined, the observations published in this Memoir, the proportion of nitrogen will be found to agree very closely with that computed by the formula, showing, as appears from the following Table, that the temperature could have varied but little since the water had been last at the surface.

Intervals of Temperature.	Mean Temperature.	Mean Amount of Nitrogen.	Computed Amount of Nitrogen.	Difference.
below 0°	—1°.1	14.32	14.65	0.33
0—3	1.2	14.19	14.12	—0.07
3—6	4.6	13.38	13.34	—0.04
6—9	7.5	12.90	12.67	—0.13
above 9	11.2	11.93	11.82	—0.11

For the temperatures under 0° the agreement is indeed not so close; but here, too, the cause may be traced to the aforesaid 5 observations from the voyage in 1877. If, however, we compute the mean temperature and the amount of nitrogen for that interval by the results of the observations instituted on the last voyage, the mean temperature will be —1.2 and the amount of nitrogen 14.59^{cc}, or only 0.09^{cc} less than that computed by the formula.

A similar computation with the observations published by Dr. Jacobsen for estimating the amount of nitrogen in the water of the North Sea, will give, in round numbers, the following results: —

Temperatur-interval.	Midlere Temperatur.	Midlere Kvælstofmængde.	Beregnet Kvælstofmængde.	Differents.
under 10°	6°.5	13.2	12.9	—0.3
10—15	12.1	12.0	11.6	—0.4
15—20	16.9	11.0	10.5[1]	—0.5

Her findes altsaa overalt en Kvælstofgehalt svarende til en noget lavere Temperatur end den observerede og det i stærkest Grad for de høiere Temperaturer, eller da Temperaturen aftager med Dybden, for de øverst liggende Vandlag. Naar man erindrer, at Jacobsens Observationer ere udførte i Eftersommeren og for det Meste paa Vandprøver fra saa smaa Dyb, at Luft- og Vandtemperaturens aarlige Variation kan tænkes at have gjort sig gjældende, vil dette ikke være saa vanskeligt at forklare gjennem Vandets Opvarmning i Sommermaanederne, medens Kvælstofmængden maa antages at rette sig efter en Temperatur mindst lige saa lav som den aarlige Middeltemperatur.

At lignende Phænomener ikke ogsaa ere observerede i de øvre Lag af det af den norske Nordhavsexpedition undersøgte Hav, har sin simple Forklaringsgrund deri, at Lufttemperaturen der selv om Sommeren ikke er høiere end Overfladetemperaturen hellere omvendt.

[1] Den for Intervallet fra 0 til 15° udledede Formel er her forudsat at gjælde ogsaa fra 15 til 20°.

Intervals of Temperature.	Mean Temperature.	Mean Amount of Nitrogen.	Computed Amount of Nitrogen.	Difference.
below 10°	6°.5	13.2	12.9	—0.3
10—15	12.1	12.0	11.6	—0.4
15—20	16.9	11.0	10.5[1]	—0.5

The proportion of nitrogen in this Table corresponds accordingly to a somewhat lower temperature than that observed, especially for the higher temperatures, or rather, since the temperature diminishes with the depth, for the upper strata of the water. If, however, we bear in mind that Jacobsen's observations were instituted at the latter end of summer, and the majority with samples of water obtained from such trifling depths that the annual variation in the temperature of air and water probably exerted some influence, this will not be difficult to account for, by reason of the heat stored in the water during the summer months, whereas the amount of nitrogen must be regulated by a temperature at least as low as the mean annual temperature.

That similar phenomena were not observed in the upper strata of the water throughout the tract of ocean investigated on the Norwegian North-Atlantic Expedition, arises simply from the fact, that the temperature of the air in those regions does not even in summer exceed that of the water at the surface, nay the reverse is rather the case.

[1] The formula deduced for the interval from 0° to 15° is here assumed to be correct for that extending from 15° to 20°.

II. Om Kulsyren i Søvandet.

Af alle de Chemikere, som før den tyske Pomerania-expedition i 1872 anstillede Undersøgelser over Luften i Søvandet, blev der foruden Bestemmelser af Surstof-Kvælstofmængden ogsaa samtidig udført Maalinger af den under Udkogningen uddrevne Kulsyre, og de Qvantiteter, man paa denne Maade fandt, bleve ogsaa bestandig opførte blandt Resultaterne som den samlede Mængde Kulsyre, der var opløst i Søvandet enten fri som Gasart eller bunden til Carbonater som sure Salte. De Resultater, som ad denne Vei erholdtes, vise imidlertid bestandig overmaade store Uoverensstemmelser ikke alene mellem de forskjellige Forfattere men ogsaa mellem de enkelte Observationer hos en og samme Experimentator, hvor man dog maatte have antaget, at en større Ensartethed i Forsøgenes Udførelse skulde have udjevnet Differentserne.

Som Exempel paa, hvor vidt Uoverensstemmelserne i de ældre Opgaver strække sig, kan anføres Følgende:

I en Liter Overfladevand fandt

Frémy	2.2	til	2.8 CC.	Kulsyre	[1].
Morren	1.6	„	3.9 —	—	[2].
Lewy	2.4	„	3.9 —	—	[3].
Pisani	6.0	„	8.1 —	—	[4].
Hunter	0.8	„	5.9 —	—	[5].

Desuden fandtes efter en noget anden Fremgangsmaade af

Bischof			39.0 CC.	[6].
Vogel	55.6	til	116.3 —	[7].

Ved alle disse ældre Undersøgelser, hvor der ved Udkogningerne var anvendt fuldt Atmosphæretryk, og hvor

[1] Compt. rend. 6—616.
[2] Ann. Chim. Phys. [3] — 12 — 5.
[3] Ann. — — [3] — 17. Ann. Chem. Pharm. 58 — 328.
[4] Compt. rend. 41 — 532.
[5] Jahresbericht 1869 — 1279.
[6] Chem. Geologie 1 Aufl. 2 — 1130.
[7] Schweigg. Journ. 8 — 351.

II. On the Carbonic Acid in Sea-water.

The several chemists who, previous to the German 'Pomerania' Expedition (1872), had instituted observations on the air present in sea-water, when measuring the amount of the oxygen and nitrogen also collected the carbonic acid driven off during the process of boiling; and the quantities determined were invariably set down among the results as the total amount of carbonic acid actually existing in the water, either free as gas or contained, to a less extent, also in bicarbonates. The results thus attained vary however to a remarkable extent, and not only as between the different experimentalists individually, — the like is also the case with the observations of one and the same person, although greater uniformity in the mode of operation should apparently have tended to eliminate error.

The following Table will show the wide difference prevailing between the formulæ of early authors.

Amount of Carbonic Acid in 1 Litre of Surface-water.

Frémy	2.2	to	2.8 CC.	[1].
Morren	1.6	„	3.9 —	[2].
Lewy	2.4	„	3.9 —	[3].
Pisani	6.0	„	8.1 —	[4].
Hunter	0.8	„	5.9 —	[5].

The proportion as found by a somewhat different process was as follows —

Bischof			39.0 CC.	[6].
Vogel	55.6	to	116.3 —	[7].

Hence, it appears that the quantity of carbonic acid given off under these early experiments, for which the boil-

[1] Compt. rend. 6, p. 616.
[2] Ann. Chim. Phys. [3] 12, p. 5.
[3] — — — [3] 17. Ann. Chem. Pharm. 58, p. 328.
[4] Compt. rend. 41, p. 532.
[5] Liebigs Jahrbericht 1869, p. 1279.
[6] Chem. Geologie 1 Aufl. 2, p. 1130.
[7] Schweigg. Journ. 8, p. 351.

derfor Temperaturen steg over 100°, undveg altsaa altid vel maalelige og ofte endog temmelig betydelige Mængder Kulsyre.

Ved de paa Pomeraniaexpeditionen i 1871 udførte Luftbestemmelser[1], hvor den tidligere beskrevne Methode med Gasarternes Udkogning under et ved Vanddamp frembragt Vacuum anvendtes, sænkedes imidlertid Temperaturen ikke ubetydeligt, og det viste sig da, at man ved denne Temperatur temmelig ofte kun fik næsten umaalelig smaa Qvantiteter Kulsyre uddrevet sammen med den øvrige Luft, medens de tidligere Uoverensstemmelser mellem flere med samme Vandprøve gjentagne Udkogninger ogsaa her gik igjen.

Jacobsen fandt sig derfor ved dette mærkelige Phænomen foranlediget til nærmere at andersøge Kulsyrens Absorbtionsforhold ligeoverfor Søvand.

Gjennem de Forsøg, som han i denne Anledning anstillede, viste det sig da, at man ad andre Veie kunde paavise aldeles uventet store Qvantiteter Kulsyre i det samme Vand, hvoraf man ved en i flere Timer fortsat Udkogning efter Bunsens Methode kun kunde erholde meget smaa Mængder. Afdestilleredes nemlig Søvandet i en kulsyrefri Luftstrøm uden Luftfortynding i en Retorte, undveg der den hele Tid Kulsyre, lige indtil den hele Mængde Vædske var afdestilleret, saaledes at man først ved rigelig Udskillelse af Salte kunde være fuldstændig sikker paa at have erholdt det samlede Udbytte af Kulsyre uddrevet.

Der lod sig under Udkogningen ikke paavise noget Punct, hvor man kunde tale om en Grændse mellem fri og surt bunden Kulsyre.

Paa denne Maade uddrev nu Jacobsen ved fuldstændig Afdestillation af $^1/_4$ Litre Søvand i en kulsyrefri Luftstrøm den hele Mængde Kulsyre og opsamlede den efter Pettenkoffers Princip i en afmaalt Mængde titreret Barytvand, som efter endt Operation retitreredes med Oxalsyre, og beregnedes efter disse den samlede Kulsyremængde, som for ufortyndet Nordsøvand opgives til omkring 100 Mgr. per Litre.

Samtidig bestemtes ogsaa i Residuet fra Inddampning af circa 10 Litre af det samme Vand den i de neutrale Carbonater indeholdte Kulsyre til i Middel kun omkring 10 Mgr. per Litre.

Ifølge disse Observationer kunde altsaa kun en meget liden Brøkdel af den ved Destillationen uddrevne Kulsyre betragtes som surt bunden, og Jacobsen imødegaar derfor i sin Afhandling bestemt den af Vierthaler[2] gjorte Antagelse, at al den ved Kogning af Søvandet uddrevne Kulsyre skulde være surt bunden. Han anser sig endvidere aldeles sikker for under Inddampningen ikke at have erholdt decomponeret nogen Del af de i Søvandet indeholdte neutrale Carbonater, idet han udtrykkelig siger: "Die ganze Menge der nicht

[1] Ann. Chem. Pharm. 167 — 1.
[2] Wien. Acad. Ber. [2] — 56 — 479.

ing-process was conducted with full atmospheric pressure, or at a temperature of more than 100° C., invariably proved appreciable, nay sometimes rather large.

When performing the air-determinations[1] on the 'Pomerania' Expedition in 1871 (by the method, previously described, of boiling out the gaseous elements in a vacuum created by steam), the temperature kept considerably lower, and the quantity of carbonic acid expelled with the other atmospheric elements at a comparatively low temperature was often immeasurably small; moreover, the variable character of the results, alluded to above, on repeating the boiling-process with the same sample of water again asserted itself.

Struck by this remarkable phenomenon, Jacobsen determined to investigate anew the absorptive capacity of sea-water in relation to carbonic acid.

The experiments of that chemist undertaken with the above object in view afforded conclusive proof of the fact, that large quantities of carbonic acid were still present in water from which a very small amount only could be expelled after several hours' protracted boiling by Bunsen's method. On distilling in a retort sea-water exposed to a current of air free from carbonic acid, but not rarified, carbonic acid is found to escape so long as any portion of the fluid remains undistilled, an abundance of solid deposit however being the only indication that all or nearly all the carbonic acid present in the water has been driven off.

During the process of boiling no particular moment could be determined marking the escape of the carbonic acid present as gas and of that which has combined with carbonates to form bicarbonates.

In this manner, by distillation in a current of air free from carbonic acid, Jacobsen succeeded in expelling the whole amount of carbonic acid contained in $^1/_4$ litre of sea-water, and collected it, by Pettenkoffer's method, in a given quantity of titrated baryta water of known strength, which, on the operation being terminated, he retitrated with oxalic acid, computing accordingly the total amount of carbonic acid driven off in the process. Undiluted North Sea water contains according to Jacobsen's results about 100^{mgr} per litre.

The amount of carbonic acid contained by the neutral carbonates in the residuary deposit from the evaporation of 10 litres of the same water, was also calculated, and found to average only about 10^{mgr} per litre.

According to these observations, a very small proportion only of the carbonic acid driven off by distillation could have been present in bicarbonates; and hence Jacobsen emphatically opposes Vierthaler's assumption,[2] that the carbonic acid boiled out of sea-water occurs in that form. Moreover, he feels quite sure that no portion of the neutral carbonates in the water examined was decomposed during the process of boiling. "Die ganze Menge," he says, "der nicht mit Basen zu neutralen Salzen verbun-

[1] Ann. Chem. Pharm. 167, p. 1.
[2] Wien. Acad. Ber. [2] 56, p. 479.

mit Basen zu neutralen Salzen verbundenen Kohlensäure erhält man aus dem Meerwasser, wenn dieses unter Durchleiten eines Stromes kohlensäurefreier Luft bis zur reichlichen Abscheidung von Chlornatrium verkocht wird."

Det maatte saaledes fremstille sig som et høist mærkeligt Phænomen, at den Kulsyre, som dog maatte tænkes opløst i Søvandet paa en eller anden Maade som fri Gasart, ikke skulde lade sig uddrive ved Udkogning efter Bunsens Methode, og at den endogsaa ved Udkogning under fuldt Atmosphæretryk og i en kulsyrefri Luftstrøm skulde undvige saa langsomt, at man først ved Concentration til omkring $^1/_{10}$ af det oprindelige Volum erholdt den sidste Rest uddrevet.

Forat kunne forklare disse Mærkeligheder tillægger Jacobsen Søvandet en eiendommelig Evne til med megen Kraft at kunne tilbageholde sin Kulsyre, en Mening, som han efter nærmere at have fremført sine Grunde mod den af Vierthaler gjorte Antagelse udtrykker med følgende Ord: "Wie man aber auch eine Deutung der starken Absorptionswirkung des Meerwassers auf die atmosphärische Kohlensäure versuchen möge, jedenfalls kann man die Kohlensäure nicht in demselben Sinne, wie Sauerstoff und Stickstoff, als absorbirtes freies Gas darin annehmen. Man mag einstweilen von einem eigenthümlichen Zustande der Bindung sprechen, bei welchem die Kohlensäure selbst durch stundenlanges Kochen nur sehr unvollständig ausgestrieben wird. Das Vorhandensein ungeheuerer Mengen Kohlensäure im Meerwasser, in einem solchen Zustande, wo sie der Athmungsluft der Seethiere nicht ohne Weiteres zugezählt werden kann, ohne andererseits der Vegetation des Meeres unzugänglich zu sein, ist jedenfalls für das maritime Thier- und Pflanzenleben von höchster Bedeutung."

Jacobsen antager nærmest at maatte henlægge denne eiendommelige Absorbtionsevne hos Søvandet til den deri opløste Chlormagnesium og henviser i saa Henseende til Egenskaber hos en Chlormagnesiumopløsning, der indeholder en i Kulsyre opløst Mængde kulsur Kalk. En saadan Opløsning kan ifølge ham henstaa i ugevis ja endog koges uden at blakkes, først ved meget langt fortsat Concentration udskiller der sig ren kulsur Magnesia.

Denne Jacobsens Anskuelsesmaade blev senere saa godt som uforandret optagen af den engelske Challenger-expeditions Chemiker, J. Y. Buchanan, som udførte en Række Forsøg[1] for nærmere at bestemme, hvilket eller hvilke af Saltene i Søvandet der skulde være i Besiddelse af denne Evne saaledes at kunne tilbageholde Kulsyren. Han kom i den Henseende til det paafaldende Resultat, at de fleste Salte, som han undersøgte, i mere eller mindre Grad skulde være i Besiddelse af denne Egenskab dog mest Sulfaterne, saaledes at denne Søvandets stærke Absorbtionsevne ligeoverfor Kulsyren af ham henlagdes fra Chlormagnesium til Sulfaterne. Ved de af ham udførte

[1] Proc. Royal Soc. 22 — 192 og 483.

denen Kohlensäure erhält man aus dem Meerwasser, wenn dieses unter Durchleiten eines Stromes kohlensäurefreier Luft bis zur reichlichen Abscheidung von Chlornatrium verkocht wird."

Hence it could not but strike the experimentalist as a remarkable phenomenon, that the carbonic acid, which in some way or other must have been held absorbed by the sea-water in a free gaseous form, should not admit of being boiled out by Bunsen's method, and that even when the boiling-process was conducted with full atmospheric pressure in a current of air free from carbonic acid, it should escape so slowly, that concentration to the extent of about one-tenth of the original volume proved necessary to obtain it all.

To account for this perplexing phenomenon, Jacobsen ascribed to sea-water a peculiar property of retaining its carbonic acid, an assumption which, after setting forth more at large the grounds that led him to oppose Vierthaler's hypothesis, he enounces in the following terms: — "Wie man aber auch eine Deutung der starken Absorptionswirkung des Meerwassers auf die atmosphärische Kohlensäure versuchen möge, jedenfalls kann man die Kohlensäure nicht in demselben Sinne, wie Sauerstoff und Stickstoff, als absorbirtes freies Gas darin annehmen. Man mag einstweilen von einem eigenthümlichen Zustande der Bindung sprechen, bei welchem die Kohlensäure selbst durch stundenlanges Kochen nur sehr unvollständig ausgestrieben wird. Das Vorhandensein ungeheuerer Mengen Kohlensäure im Meerwasser, in einem solchen Zustande, wo sie der Athmungsluft der Seethiere nicht ohne Weiteres zugezählt werden kann, ohne andererseits der Vegetation des Meeres unzugänglich zu sein, ist jedenfalls für das maritime Thier- und Pflanzenleben von höchster Bedeutung."

Jacobsen is of opinion, that this peculair absorptive power must be derived from the chloride of magnesia present in sea-water, and draws attention to certain properties possessed by a solution of chloride of magnesia containing carbonate of lime dissolved in carbonic acid. A solution of this kind may, according to his statement, be left exposed for weeks together, nay be boiled even, without becoming turbid; nor can it be made to part with pure carbonate of magnesia till after protracted concentration.

Jacobsen's hypothesis was subsequently adopted, almost without modification, by J. Y. Buchanan, chemist to the 'Challenger' Expedition, who instituted a series of experiments[1] with a view to determine which of the salts present in sea-water had this property of retaining carbonic acid. He arrived at the surprising conclusion, that most of the salts examined were in some degree distinguished by this property, chiefly however the sulphates; and the remarkable power possessed by sea-water of retaining carbonic acid he transferred accordingly from chloride of magnesia to the sulphates. Hence, when performing carbonic acid determinations he always precipitated the sulphuric

[1] Proc. Royal Soc. 22, pp. 192 and 483.

Kulsyrebestemmelser pleiede han derfor altid før Operationens Begyndelse at udfælde Svovlsyren med concentreret Chlorbariumopløsning, forat Kulsyren lettere skulde undvige, men anvendte forresten den af Dr. Jacobsen angivne Methode, hvorved han har bestemt Kulsyren i Søvandet i de sydlige Have til i Middel 43.26 Mgr. per Litre[1].

Da jeg Vaaren 1877 opfordredes til at gaa ud som Chemiker paa den norske Nordhavsexpeditions 2det Togt, var der kun levnet mig nogle faa Dage til Forberedelser, og det følger derfor af sig selv, at jeg ikke paa nogen Maade dengang kunde have befattet mig med vidtløftigere Forundersøgelser, og jeg maatte saaledes uden selv at kunne prøve optage de tidligere Methoder uforandrede. Paa Togtet i 1877 anvendtes derfor den af Dr. Jacobsen angivne Methode, og bestemtes efter denne gjennem en Række omhyggelig udførte Observationer Kulsyregehalten i det da undersøgte Hav til omkring 100 Mgr. per Litre. Der viste sig imidlertid ved Gjentagelse af samme Observation bestandig Uoverensstemmelser, som ofte vare ikke ubetydelige og engang endog løb op til hele 12 Mgr. per Litre.

Dels herved dels ved andre Omstændigheder vaktes min Mistanke om Tilforladeligheden af den af Dr. Jacobsen i Forslag bragte Methode.

Det syntes mig paa Forhaand overmaade urimeligt, at der hos Søvandet skulde findes en saadan mærkelig Evne til rent mekanisk at tilbageholde den ene Gasart, medens den ingensomhelst Virkning skulde udøve paa de Andre. Heller ikke var der nogensinde gjort noget Forsøg paa at sætte dette Phænomen i Forbindelse med bekjendte chemiske Egenskaber hos nogen af de i Søvandet indeholdte Stoffe.

Ved et Tilfælde kom jeg en Dag til at forsøge Søvandets Reaktion paa Lakmus og Rosolsyre og fandt til min sore Forundring, at det reagerede bestemt og tydeligt alkalisk, hvad jeg siden har bragt i Erfaring, at allerede v. Bibra[2] og senere E. Guignet og A. Telles[3] har observeret.

Efter mine Forsøg viser to ligestore Prøver af en efter Gottliebs[4] Fremgangmaade frisk tilberedt Lakmusopløsning, hvoraf den Ene tilsættes en tilstrækkelig Mængde Søvand og den Anden et ligestort Volum rent destilleret Vand, ikke ubetydelige Farvedifferentser. Ligeledes antager en med meget fortyndet Oxalsyre svagt udsyret passende Portion rent Vand, hvori paa Forhaand er opløst en Draabe Rosolsyre, ved Tilsætning af Søvand strax den bekjendte rødlig-violette Farve.

Paa denne Maade undersøgtes paa Expeditionens sidste Togt, hvor der var fuld Anledning til at erholde Vandprøverne ganske friske, et meget stort Antal af disse og uden Undtagelse med det samme ovenbeskrevne Resultat.

---

[1] Ber. Berl. chem. Ges. 11 — 410.
[2] Ann Chem. Pharm. 77 — 90.
[3] Compt. rend. 83 — 919.
[4] Journ. für pract. Chem. 107 — 488.

acid, before commencing the operation, by adding to the water a saturated solution of chloride of barium, in order to facilitate the liberation of the carbonic acid, but, with this exception, adopted the method devised by Dr. Jacobsen, and determined the mean amount of carbonic acid present in the water of the Southern Seas to be 43.26^{mgr} per litre.[1]

When invited, in the spring of 1877, to go out as chemist to the Norwegian North-Atlantic Expedition, on the second cruise, I had but a few days in which to make the necessary preparations, and consequently no time being left me for preliminary experiments, I was compelled to adopt unchanged the earlier methods, without testing the accuracy of their results. On the cruise in 1877, I therefore applied Dr. Jacobsen's method, and determined by a series of careful observations the amount of carbonic acid present in the water of the tract then investigated to be about 100^{mgr} per litre. But, on repeating the operation with the same sample of water, the results were always found to vary, and frequently indeed considerably; nay, on one occasion the difference amounted to as much as 12^{mgr} per litre.

Partly for this reason, and partly from other circumstances, I was led to question the trustworthiness of Jacobsen's method.

Now it struck me at once as highly improbable that sea-water should possess so remarkable a power of retaining mechanically one gas, and yet, in this respect, exert no influence whatever on others. Nor had any attempt been made to connect this phenomenon with known chemical properties distinguishing the substances contained in sea-water.

Quite accidentally, I was one day led to investigate the effect of sea-water as a reagent on litmus and rosolic acid, and found its reaction, to my great surprise, distinctly alkaline, which, indeed, as I subsequently learnt, had been already observed, first by von Bibra[2] and later by E. Guignet and A. Telles.[3]

According to my experiments, two equal measures of a solution of litmus, freshly prepared by Gottlieb's method,[4] one of which has added to it a sufficient quantity of sea-water and the other an equal volume of pure distilled water, exhibit considerable difference in colour. Moreover, a proportionate mixture of highly dilute oxalic acid and pure water, the latter having been previously treated with a drop of rosolic acid, will, on the addition of sea-water, immediately assume the well known reddish-violet hue.

In this manner were examined on the last cruise of the Expedition, which afforded excellent opportunities of obtaining the water quite fresh, a very large number of samples, and invariably with the results described above.

---

[1] Ber. Berl. chem. Ges. 11, p. 410.
[2] Ann. Chem. Pharm. 77, p. 90.
[3] Compt. rend. 83, p. 919.
[4] Journ. für pract. Chem. 107, p. 488.

Dette syntes ogsaa meget vanskeligt at forklare, saafremt det virkelig skulde forholde sig som af Enkelte paastaaet, at der i Søvandet skulde findes et meget stort Overskud af fri Kulsyre ved Siden af en meget liden Qvantitet af sure Carbonater. Det maatte aabenbart synes meget rimeligere at forklare de af Dr. Jacobsen gjorte Observationer derved, at Søvandet under den langvarige Kogning ved en eller anden chemisk Reaction gav Slip paa noget af sin neutralt bundne Kulsyre.

For at komme paa det Rene med, om dette virkelig forholdt sig saa, gik jeg frem paa følgende Maade:

200 CC. Søvand (af sp. Vægt 1.0267 ved 17.°5 C. i Forhold til destilleret Vand af samme Temperatur) afdestilleredes næsten til Tørhed i en kulsyrefri Luftstrøm, og opfangedes den undvigende Kulsyre i 25 CC. af en Barytopløsning, hvoraf 1 CC. svarede til 4.0204 Mgr. Kulsyre. Ved Retitration med Oxalsyre viste det sig, at 19.97 CC. af det anvendte Barytvand var uneutraliseret, hvoraf den undvegne Kulsyre beregnedes til 20.2 Mgr. Residuet paaheldtes nu friskt udkogt Vand, som atter afdestilleredes, hvorved endnu et ubetydeligt Spor af Kulsyre erholdtes. Sluttelig tilsattes circa 0.5 Gr. fuldkommen ren friskt udglødet Soda, hvorpaa det Hele atter fortyndedes med kulsyrefrit Vand til Søvandets oprindelige Volum og saa afdestilleredes i en kulsyrefri Luftstrøm.

Allerede fra det Øieblik af, da Vædsken var kommen i Kog, begyndte strax en saa voldsom Kulsyreudvikling, at det i Forlaget anbragte Barytvand slap store Mængder uabsorberede igjennem, og det viste sig efter endt Operation, at kun 1.3 CC. Barytvand var forblevet uneutraliseret. Heraf beregnes den absorberede Del af den undvegne Kulsyre til 95.3 Mgr., medens desforuden meget betydelige Mængder gik igjennem, idet nemlig Barytvandet i et uformigt Rør, som var anbragt foran Forlaget, fuldstændigt var forbrugt.

Efter Forslag af Professor Waage gjentoges Forsøget med varmt fældt, ved 100° tørret kulsur Kalk, hvoraf det ogsaa lykkedes at uddrive ikke ubetydelige om end meget mindre Mængder Kulsyre, hvorimod der ved et Forsøg med fint pulveriseret Marmor ikke erholdtes noget sikkert Resultat.

Betydningen af disse Observationer kunde ikke være tvivlsom, da det hermed paa det Tydeligste var godtgjort, at den i Søvandet forhaandenværende Saltblanding ved Koghede decomponerede neutrale Carbonater, og dermed ogsaa, at alle de hidindtil gjorte Kulsyrebestemmelser med Hensyn paa sin Hensigt at bestemme den i Søvandet indeholdte frie og surt bundne Kulsyre vare forfeilede. Hvad angaar de før Publicationen af Dr. Jacobsens Afhandling om Luften i Søvandet udførte Kulsyrebestemmelser, da er det en Selvfølge, at de alle uden Undtagelse maatte være i enhver Henseende fuldstændig værdiløse, idet der ved dem intetsteds er kommen til Anvendelse en Afdestillation til Tørhed eller en saa vidtdreven Concentration, at man

This fact would obviously be most difficult of explanation if, as some have affirmed, sea-water does actually contain a very large surplus of free carbonic acid along with an exceedingly small proportion of bicarbonates. A more plausible hypothesis by which to explain Dr. Jacobsen's observations were surely the assumption, that during the protracted process of boiling some of the neutral carbonates present in sea-water had been decomposed.

With the object of ascertaining whether such was really the case, I went to work as follows.

Two hundred c.centim. of sea-water (sp. grav. 1.0267, temp. 17.°5 C., as compared with distilled water of the same temperature) were distilled almost to dryness in a current of air free from carbonic acid, and the carbonic acid collected in 25^{cc} of baryta water, 1^{cc} of which represented 4.0204^{mgr} carbonic acid. On being retitrated with oxalic acid 19.97^{cc} of the baryta water were found not to be saturated, and 20.2^{mgr} carbonic acid had accordingly been driven off. Water freshly boiled was now poured on the residue, and then evaporated, the result yielding a slight trace of carbonic acid; finally, about 0.5^{mgr} purified and freshly heated soda was added, and the whole compound again diluted with water, from which all carbonic acid had been expelled, to the original volume of the sample, and then distilled in a current of air free from carbonic acid.

From the very moment at which the fluid began to boil, so rapid was the liberation of carbonic acid that large quantities passed unabsorbed through the baryta water; and, on the operation being terminated, 1.3^{cc} only of the baryta water had not been neutralised. Hence the absorbed portion of the carbonic acid was calculated at 95.3^{mgr}, exclusive of which a very considerable quantity, as before stated, passed off into the atmosphere, the baryta water, placed in a glass tube (resembling in form the letter *U*) connected with the receiver, being surcharged with the gas.

At Professor Waage's suggestion I repeated the experiment with carbonate of lime, precipitated warm and dried at a temperature of 100° C., and succeeded in expelling carbonic acid in considerable, though not so large, quantities as before, whereas an experiment with finely pulverised marble gave no positive result.

The importance of these observations was not to be questioned, affording as they did conclusive proof that the saline mixture in sea-water, on the temperature being raised to the boiling point, decomposed neutral carbonates, and likewise that all carbonic acid determinations hitherto attempted with the object of measuring the carbonic acid present in sea-water were faulty. As regards the carbonic acid determinations performed previous to the publication of Dr. Jacobsen's Memoir on the presence of air in sea-water, such must as a matter of course be wholly worthless, the method of distillation to dryness having in no case been adopted, or that of concentrating the fluid till further evaporation ceased to expel carbonic acid. The

ikke ved fortsat Inddampning skulde kunne have erholdt et større Udbytte af Kulsyre. De af Dr. Jacobsen og J. Y. Buchanan udførte Observationer kunde derimod ikke saa ligefrem forkastes, idet der jo kunde tænkes Mulighed for, at det ved de af dem benyttede Methoder kunde have lykkedes ved den langvarige Kogning at uddrive ogsaa al neutralbunden Kulsyre, i hvilket Fald de af dem opførte Tal i en anden Henseende kunde faa Betydning nemlig som Udtryk for den samlede Sum af den i Søvandet indeholdte Kulsyre.

Desværre lagde flere Omstændigheder Hindringer i Veien for Afslutningen af mine Forsøg over disse Gjenstande i Vinteren 1877—78, dels var min Tid optaget med andre Arbeider, dels lod min Helbred den største Del af Vinteren adskilligt tilbage at ønske, saaat mine Forsøg ingenlunde havde den ønskelige Fremgang, og jeg blev derfor nødt til at gaa ud ogsaa paa Togtet i 1878 uden nogen paalidelig Methode til Bestemmelse af den i Søvandet indeholdte Kulsyre. Da jeg efter endt Togt om Høsten vendte tilbage, gjenoptog jeg imidlertid atter mine Undersøgelser og bragte dem til Afslutning.

Gjennem en netop da af C. Borchers offentliggjort Afhandling[1] om Bestemmelsen af Kulsyren i naturlige Mineralvande blev jeg gjort opmærksom paa det for Bestemmelse af Kulsyren i Carbonater af Alexander Classen angivne Apparat,[2] som jeg senere i stor Udstrækning har benyttet.

Apparatet i den Form, hvori det her er kommen til Anvendelse, findes sammenstillet i Figur 3.

A er 2 med Natronkalk fyldte uformige Rør, *B* indeholder Barytvand. *C* er en Erlenmeyers Kolbe paa circa 0.5 Litre, der gjennem et ved Bunden udmundende Rør communicerer med *B*, medens et lige under Kautschukproppen udmundende sætter den i Forbindelse med Kjøleleren *D*, hvis indre Del efter Classen bestaar af et 27—30^{mm} vidt Glasrør, hvortil i øvre og nedre Ende er loddet Rør med respective 15 og 7^{mm} Diameter. Forlaget *E* er fuldstændig af samme Construction som det af Jacobsen benyttede og er oventil forsynet med det af P. Wagner[3] foreslaaede med Glaskugler fyldte Rør *F*.

Ved *a*, hvor der findes en Indsnevring, er anbragt en noget større Glaskugle, som temmelig nøie dækker over det nederste snevre Rør. Idet det til Opsamling af Kulsyren anvendte titrerede Barytvand heldes ned gjennem *F*, fjernes Proppen *b*, indtil det Meste af Barytvandet har passeret *a*, men sættes derpaa hurtigt i, saaledes at der over de nederste Glaskugler bliver staaende noget Barytvand til en Høide af omtrent 50^{mm} over *a*. Dersom nu

[1] Journ. für pract. Chem. 125 — 353.
[2] Fresenius Zeitschrift 15 — 288.
[3] Fresenius Zeitschrift 9 — 445,

series of observations instituted by Dr. Jacobsen and J. Y. Buchanan cannot however be wholly rejected, since the protracted boiling characteristic of the method they adopted may possibly have driven off all the carbonic acid contained in the carbonates, in which case their figures would acquire importance as expressive of the total amount of carbonic acid present in the sea-water examined.

Unfortunately, divers untoward circumstances conspired to prevent my terminating in the winter of 1877—78 the series of experiments I had begun with the object of elucidating this intricate subject; my time, for instance, came to be unexpectedly occupied in other ways, and during the greater part of that period I suffered from ill-health. My observations, therefore, not having progressed so favourably as I at first had reason to anticipate, I was again obliged to set out on the Expedition, in 1878, without having fixed on any reliable method for determining the carbonic acid present in sea-water. On my return however to Christiania in the autumn of that year, I recommenced the said experiments, and succeeded in bringing them to a satisfactory termination.

A paper by C. Borchers, which had just appeared,[1] on the determination of carbonic acid in mineral water, drew my attention to the apparatus — of which I have since made frequent use — devised by Alex. Classen[2] for determining carbonic acid in carbonates.

Figure 3 represents this apparatus as constructed for my experiments.

A 2 glass tubes, resembling in form the letter *U*, filled with soda-lime; *B* a vessel for baryta water; *C* an Erlenmeyer flat-bottomed matrass, containing about 0.5 litre, which by means of a tube terminating at the bottom is made to communicate with *B*, a similar tube, issuing immediately beneath the caoutschouc stopper, putting it likewise in communication with the cooler *D*, the inner portion of which, according to Classen, should consist of a glass tube from 27^{mm} to 30^{mm} in diameter, with tubes, measuring respectively 15^{mm} and 7^{mm} in diameter, sealed to its upper and lower extremities. The receiver *E* has precisely the same form as that adopted by Jacobsen, and is furnished above with a glass tube, *F*, filled with glass balls, as suggested by P. Wagner.[3]

At the point *a*, where the tube suddenly narrows, is introduced a somewhat larger glass ball, to fill up, as near as may be, the opening of the lower or slender portion of the tube. When the titrated baryta water, which absorbs the carbonic acid, is being poured down through *F*, the stopper *b* has to be taken out, but must be quickly replaced, before the whole of the fluid has passed *a*, in order that the glass balls to a height of about 50^{mm} above *a*

[1] Journ. für pract. Chem. 125, p. 353.
[2] Fresenius Zeitschrift 15, p. 288.
[3] Fresenius Zeitschrift 9, p. 445.

den nederste Glaskugle slutter godt, vil den gjennem *a* passerende Luft spaltes i en Mængde meget fine Blærer, som ved at stige op mellem de af Barytvand omgivne Glaskugler bliver fuldstændig kulsyrefri. Det uformige Rør *G* indeholder Barytvand, *H* fører til Aspiratoren.

may be immersed in baryta water. Now, assuming the large glass ball to fit well, the air will pass *a* in the form of minute bubbles, which, having to ascend between the glass balls surrounded by baryta water, must part with the whole of its carbonic acid. The tube *G* contains baryta water; *H* leads to the aspirator.

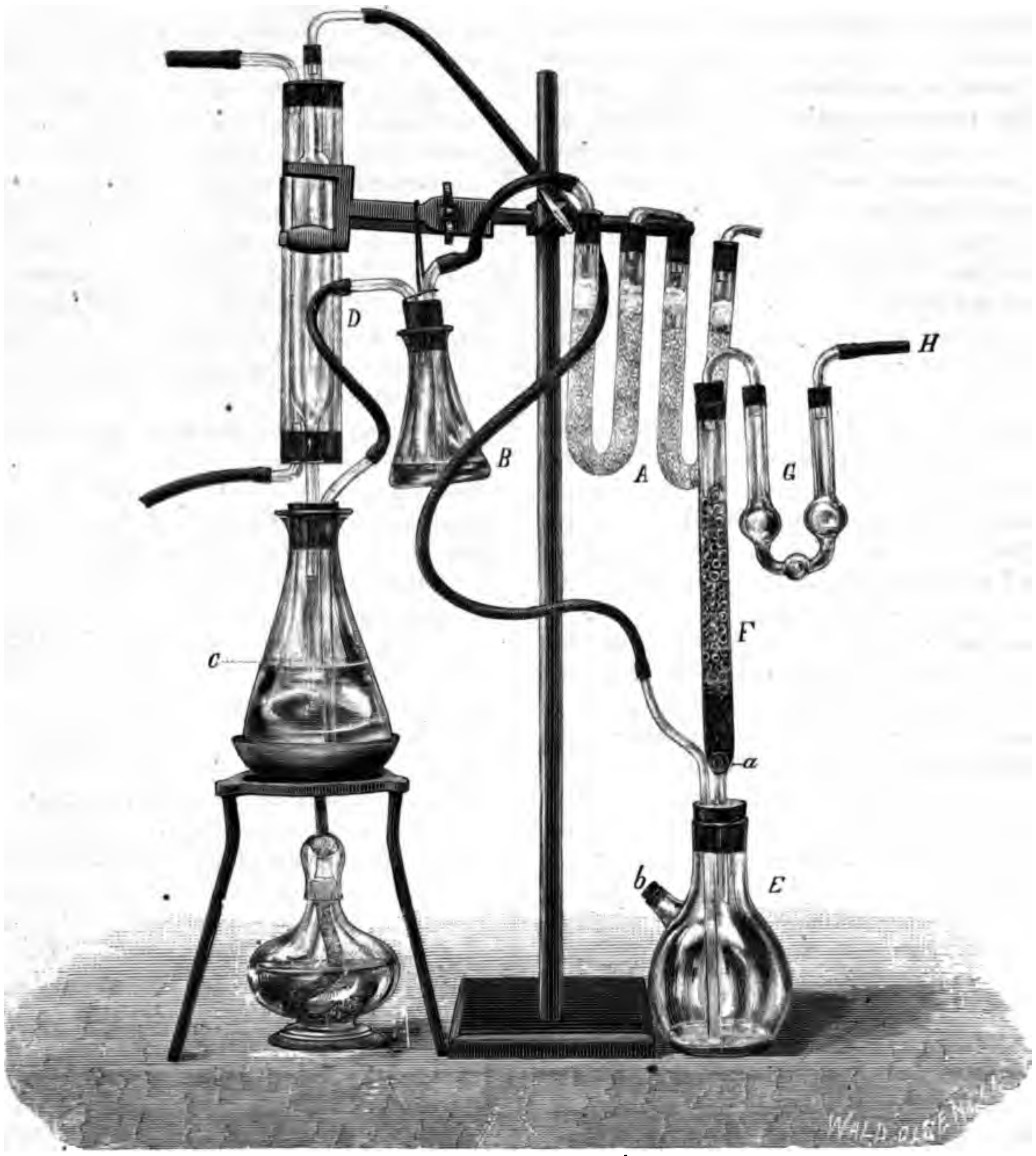


Fig. 3.

Den af Classen foreslaaede Kjøler virker saa udmærket, at man i meget lang Tid kan koge fortyndet Saltsyre i Kolben, uden at det mindste Spor af Chlor kan paavises i Forlaget, forudsat at den gjennemledede Luftstrøm ikke gives for stor Hastighed, hvad der imidlertid heller ikke er fornødent.

The cooler devised by Classen is so excellent, that diluted hydrochloric acid may be boiled in the matrass for a very considerable length of time without a trace of acid being detected in the receiver, provided that too great rapidity be not given to the current of air; this, however, is quite unnecessary.

Naar Søvandet i dette Apparat kogtes med fortyndet Svovlsyre i en kulsyrefri Luftstrøm, undveg Kulsyren meget hurtigt, idet 15 Minutters Kogning fuldstændig strak til for at bringe al Kulsyre over i Forlaget. Søvandets Sulfater viste altsaa i alle Fald ikke ved Tilstedeværelsen af fri Syre de af J. Y. Buchanan observerede Egenskaber. Naar den paa denne Maade uddrevne Kulsyremængde opsamledes og bestemtes, viste den sig altid at stemme nogenlunde med, hvad man efter den af Dr. Jacobsen anvendte Methode kunde erholde uddrevet, idet de optrædende Afvigelser snart vare positive snart negative men i Regelen ikke større, end at de for den største Del maatte kunne tilskrives Observationsfeil. Ved den af Buchanan i Forslag bragte Udfældning af Svovlsyren erholdt jeg derimod bestandig betydelig for lave Resultater, hvorom senere.

For samtidig i en og samme Portion at kunne bestemme baade den neutralbundne og den samlede Mængde Kulsyre, anvendte jeg følgende Fremgangsmaade.

Efterat Apparatet fuldstændig var befriet for kulsyreholdig Luft, anbragtes i Forlaget paa den før beskrevne Maade 25 CC. Barytvand, hvoraf hver CC. svarede til 4,129 Mgr. Kulsyre, hvorefter der i Kolben C heldtes 367.7 CC. af det til Undersøgelse bestemte Søvand tilligemed 10 CC. af en Svovlsyre, hvoraf hver CC. svarede til 4.099 Mgr. Kulsyre. Indholdet i Kolben ophededes nu under Gjennemledning af en meget langsom Luftstrøm til Koghede og holdtes i Kog i nogen Tid. Efter Forløb af henimod 15 Minutter fjernedes atter Varmekilden og Vædsken afkjøledes, idet Luftstrømmen lidt efter lidt gaves en noget større Hastighed, hvorved den endnu ikke absorberede Kulsyre meget hurtigt bragtes over i Forlaget.

Efter endt Operation bragtes de i F værende Glaskugler tilligemed det ved Rørets Vægge heftende Barytvand ned i Forlaget E, hvorpaa det Hele retitreredes med en Oxalsyre, hvoraf hver CC. svarede til 3.976 Mgr. Kulsyre, idet alkoholisk Curcuma tjente som Index. Ligeledes skylledes den ved de indre Vægge af Kjøleren heftende Vædske ved lidt kulsyrefrit destilleret Vand ned i Kolben, hvori den overskydende Syre neutraliseredes med en Natronlud, hvoraf hver CC. svarede til 2.928 Mgr. CO_2, idet Rosolsyre tjente som Index.

Som Resultat af disse Titreringer erholdtes den samlede Kulsyremængde bestemt til omkring 97 Mgr. og den neutralbundne til gjennemsnitlig henimod 53 Mgr. pr. Litre. De 44 Mgr. Kulsyre, som udgjør Differentsen mellem den samlede Kulsyremængde og den neutralbundne, kan aabenbart ikke forekomme i Søvandet som fri Gasart, men maa forene sig med de allerede færdigdannede Carbonater under Dannelsen af Bicarbonater, og det viser sig altsaa, at de af Dr. Jacobsen gjorte Observationer meget naturligt lade sig forklare derved, at Søvandet ikke indeholder det mindste Spor af fri Kulsyre men hele 53 Mgr. neutralbunden og kun omkring 44 Mgr. surtbunden Kulsyre pr. Litre.

On boiling sea-water along with diluted sulphuric acid, exposed to a current of air free from carbonic acid, in this apparatus, carbonic acid escaped very rapidly, the space of 15 minutes sufficing to collect the whole of it in the receiver. The sulphates in sea-water — at least when free acids were present — did not, accordingly, exhibit the properties ascribed to them by J. Y. Buchanan. On collecting and determining the carbonic acid driven off by this process, the amount was invariably found to agree with that which could be liberated by Dr. Jacobsen's method, the differences observed having been sometimes positive and sometimes negative, but as a rule not greater than would admit of imputing them chiefly to errors of observation. On precipitating the sulphuric acid as suggested by Buchanan, the results obtained were invariably too low; but to this subject I shall afterwards return.

In order to determine both the proportion of carbonic acid forming the neutral carbonates and the whole amount of carbonic acid contained in one and the same sample of sea-water, I adopted the following mode of procedure.

After expelling from the apparatus all air in which carbonic acid was present, 25^{cc} of baryta water were introduced, as previously described, into the receiver, each c.centim. representing 4.129^{mgr} carbonic acid; 367.7^{cc} of the sea-water to be examined were then poured into the matrass (C), along with 10^{cc} of sulphuric acid, each c.centim. of which represented 4.099^{mgr} carbonic acid. The contents of the matrass were now heated, during exposure to a very slow current of air, up to the boiling-point, and kept for some time at that temperature. After the lapse of about 15 minutes, the source of heat was removed and the fluid cooled, the rapidity of the current of air being slightly increased, causing the carbonic acid not yet absorbed to pass off quickly into the receiver.

The operation being terminated, the glass balls in the tube F, along with the baryta water adhering to the walls of the tube, were introduced into the receiver E, and the whole of its contents retitrated with oxalic acid, each c.centim. of which represented 3.976^{mgr} carbonic acid, a solution of alcoholic curcuma serving as the index. The fluid adhering to the walls of the cooler was likewise washed down into the matrass with a little distilled water free from carbonic acid, and the surplus acid neutralised by the addition of soda-lye, each c.centim. of which represented 2.928^{mgr} CO_2, rosolic acid serving as the index.

As the result of this titration, the total amount of carbonic acid was found to be about 97^{mgr} and the proportion forming neutral carbonates to average about 53^{mgr} per litre. Now, the difference, 44^{mgr}, cannot occur free as gas, but will unite with the carbonates to form bicarbonates; and hence Dr. Jacobsen's observations could be readily explained on the assumption that sea-water contains no trace even of free carbonic acid, but as much as 53^{mgr} per litre of carbonic acid forming carbonates and only about 44^{mgr} per litre of carbonic acid forming bicarbonates.

Som man ser, er den her til Bestemmelse af den neutralbundne Kulsyre anvendte Methode i alt væsentligt den samme, som allerede for flere Aar tilbage er beskreven af Dr. Mohr.[1] Forskjellen stikker kun deri, at jeg har anvendt Classens Kjøler og desuden ombyttet Salpetersyren med Svovlsyre. Det syntes mig nemlig ikke tilraadeligt at anvende Salpetersyre ligeoverfor et saa stærkt chlorholdigt Mineralvand som Søvand, hvori der desuden fandtes en vel mærkbar om end temmelig liden Qvantitet oxyderbare Stoffe.

Efter denne Fremgangsmaade har jeg senere ved 78 Observationer bestemt Kulsyren i 64 forskjellige Vandprøver temmelig jevnt fordelte over det af den norske Nordhavexpedition undersøgte Felt. Resultaterne findes sammenstillede i Tabel II.

Først skal i Korthed berøres de Feil, hvormed de i Tabellen opførte Tal kan tænkes beheftede.

Om man vilde antage, at den i Søvandet indeholdte Kiselsyre ikke forekom opløst som fri Syre, men forefandtes bundet til Baser i Form af Silicater, en Antagelse af meget tvivlsom Berettigelse, vilde man aabenbart efter den ovenfor beskrevne Methode faa noget feilagtige Resultater, idet den til Kiselsyre bundne Mængde Baser vilde findes som bunden til Kulsyren. Forat kunne danne mig en Forestilling om, hvorvidt den Feil, som man under denne Forudsætning skulde kunne begaa, nogensinde vil kunne tænkes at faa særlig Betydning, har jeg bestemt Kiselsyremængden i forskjellige af de hjembragte Vandprøver, idet følgende Fremgangsmaade er kommen til Anvendelse. 0.5 Litre Søvand inddampedes med lidt Saltsyre i en Platinaskaal først over fri Ild senere paa Vandbad til Tørhed og tørredes ved 110°—120° C. Saltene udtoges derpaa og pulveriseredes bedst muligt i en vel poleret Agatriveskaal, hvorpaa de atter tørredes ved samme Temperatur, og sluttelig bragtes over i et passende Kar og tilsattes ca. 200 CC. saltsyreholdigt Vand, hvorved al Gips fuldstændigt opløstes. De paa denne Maade udskilte Kiselsyremængder vare altid meget smaa og maatte nærmest blive at betegne som Spor, idet de, hvor jeg forsøgte at veie dem, kun beløb sig til Brøkdele af Mgr. i den anvendte Portion Vand. Dette stemmer paa det Nøieste med, hvad Thorpe og Morton nylig har fundet i det irske Hav,[2] hvorimod de ældre Opgaver giver noget større Tal. Og man vil saaledes se, at der ingensomhelst Rimelighed er for, at den i Søvandet indeholdte Kiselsyremængde skulde bidrage til i mærkelig Grad at gjøre de fundne Resultater upaalidelige.

Naar man skal danne sig en Mening om Nøiagtigheden af disse Observationer, er det imidlertid nødvendigt at tage Hensyn til en anden Omstændighed, som kunde tænkes at have havt sin Indflydelse paa Resultaterne.

[1] Mohr Titrirmethode 3te Aufl. — 524.
[2] Ann. Chem. Pharm. 158 — 122.

As will be seen, the method adopted for the determination of the carbonic acid forming carbonates, was essentially the same as that described by Dr. Mohr[1] several years previously. The only difference lay in my having employed Classen's cooler and made choice of sulphuric acid in preference to nitric. It did not seem advisable to use nitric acid when examining a mineral water so rich in chlorine as is sea-water, and which besides contains a quantity, small indeed but appreciable, of organic matter.

By this process I subsequently determined the carbonic acid in 64 different samples of sea-water, drawn at comparatively regular intervals from the tract of ocean investigated on the Norwegian North-Atlantic Expedition; the number of observations amounted to 78. The results are given in Table II.

I will first say a few words respecting the errors that may possibly affect the accuracy of the figures set down in the Table.

Assuming the silicic acid in sea-water not to occur as a free acid, but combined with bases in the form of silicates, an hypothesis of very doubtful value, the results obtained by the method described above would be obviously to some extent inaccurate, inasmuch as the bases combined with silicic acid must in that case have behaved as if originally combined with carbonic acid. In order to ascertain what importance could possibly be attached to an error arising on such an assumption, I determined the amount of silicic acid in divers of the samples of sea-water brought home with me, adopting for that purpose the following method. Five-tenths of a litre of sea-water mixed with a little hydrochloric acid were evaporated to dryness in a platinum dish, at first over a common fire and then in a water-bath, and dried at a temperature of 110°—120° C. The salts were then taken out and transferred to a well polished agate dish, in which they were finely pulverised, and again dried at the same temperature; finally they were placed in a suitable vessel, and mixed with about 200^{cc} of water containing hydrochloric acid, which thoroughly dissolved all the gypsum. The amounts of silicic acid thus precipitated were invariably very small, indeed but little more than traces; for, on attempting to weigh them, they proved to be but fractions of a milligramme. This result agrees exactly with the observations of Thorpe and Morton on water from the Irish Sea,[2] whereas the figures in earlier statements are somewhat higher. Hence, there is no reason whatever to assume, that the silicic acid present in sea-water should to any considerable extent influence the results obtained.

When judging of the accuracy of these observations, regard must, however, be had to another circumstance that might possibly in some measure affect the results. The water examined did not consist of freshly drawn samples,

[1] Mohr's Titrirmethoden 3te Aufl. p. 524.
[2] Ann. Chem. Pharm. 158, p. 122.

Tabel II.

No.	Stat. No.	Nordlig Bredde. (*North Latitude.*)	Længde fra Greenwich. (*Longitude from Greenwich.*)	Dybde hvorfra Prøven hentet. (*Depth from which the Samples were collected.*) Engelske Favne. (*English Fathoms.*)	Meter. (*Metres.*)	Temperatur. Celsius.	Neutralbunden Kulsyre. (*Carbonic Acid forming Carbonates.*) Mgr. per Litre.	Surtbunden Kulsyre. (*Carbon. Acid forming Bicarbonates.*) Mgr. per Litre.	Anmærkninger. (*Remarks.*)
1	—	Jæderen.		0	0	?	52.3	41.1	
2	51	65° 53′	7° 18′ W.	1163	2127	—1.1	52.6	46.7	
3	52	65 47.5	3 7	1861	3403	—1.2	52.7	46.9	
4	52	65 47.5	3 7	1861	3403	—1.2	52.9	46.1	
5	53	65 13.5	0 33 E.	1539	2814	—1.3	53.1	43.8	
6	53	65 13.5	0 33	0	0	10.5	54.3	40.4	
7	143	66 58	10 33	189	346	6.2	53.8	43.3	
8	143	66 58	10 33	0	0	8.2	53.4	41.5	
9	183	69 59.5	6 15	1600	2926	—1.2	52.6	44.8	
10	183	69 59.5	6 15	0	0	8.6	53.5	44.8	
11	184	70 4	9 50	1547	2829	—1.3	53.0	45.5	
12	184	70 4	9 50	600	1097	0.0	52.4	44.7	
13	184	70 4	9 50	0	0	7.6	53.8	40.9	
14	187	69 51.5	14 41	1335	2441	—1.1	53.8	43.1	
15	189	69 41	15 42	860	1573	—1.1	53.0	45.5	
16	189	69 41	15 42	860	1573	—1.1	52.7	43.6	
17	189	69 41	15 42	0	0	9.6	54.2	41.8	
18	215	70 53	2 0 W.	0	0	8.0	54.2	41.4	
19	215	70 53	2 0	200	366	2.8	52.6	—	
20	215	70 53	2 0	200	366	2.8	52.6	46.8	
21	217	71 0	5 8	0	0	4.6	52.7	41.3	
22	226	70 59	7 51	340	622	—0.6	54.3	46.4	
23	226	70 59	7 51	340	622	—0.6	54.6	46.0	
24	226	70 59	7 51	340	622	—0.6	54.7	—	
25	226	70 59	7 51	0	0	3.0	52.2	40.7	
26	226	70 59	7 51	0	0	3.0	52.2	41.6	
27	237	70 41	10 10	0	0	3.0	53.4	42.4	
28	237	70 41	10 10	0	0	3.0	54.5	39.7	
29	240	69 2	11 26	0	0	4.2	55.0	44.4	
30	240	69 2	11 26	0	0	4.2	55.4	—	
31	—	68 33	7 25	0	0	6.0	53.0	45.0	
32	—	68 33	7 25	0	0	6.0	53.0	43.9	
33	243	68 32.5	6 26	1385	2533	—1.3	53.7	42.4	
34	245	68 21	2 5	0	0	9.0	53.8	45.2	
35	245	68 21	2 5	0	0	9.0	53.8	44.2	
36	247	68 5.5	2 24 E.	500	914	—0.4	53.9	47.3	
37	247	68 5.5	2 24	0	0	9.4	54.0	47.2	
38	264	70 56	35 37	0	0	5.2	51.8	42.3	
39	264	70 56	35 37	86	157	1.9	52.6	43.2	
40	275	74 8	31 12	0	0	2.9	53.0	45.3	
41	284	73 1	12 58	0	0	6.8	52.6	43.2	
42	295	71 59	11 40	0	0	7.0	52.8	42.4	
43	295	71 55	11 30	100	183	3.2	51.9	42.8	
44	295	71 55	11 30	600	1097	—0.8	52.6	43.7	
45	295	71 59	11 40	1110	2030	—1.3	53.8	43.1	
46	297	72 36.5	5 12	0	0	4.6	52.6	43.7	
47	297	72 36.5	5 12	1280	2341	—1.4	52.1	43.4	
48	298	72 52	1 50.5	1500	2743	—1.5	52.2	42.9	
49	300	73 10	3 22 W.	0	0	1.7	48.6	43.4	Øst lige ved Kanten af Grønlandsisen. (Drawn in immediate proximity to the Greenland Ice.)
50	300	73 10	3 22	0	0	1.7	48.4	42.0	
51	303	75 12	3 2 E.	0	0	3.3	52.2	47.9	
52	303	75 12	3 2	0	0	3.3	51.8	48.0	
53	303	75 12	3 2	150	274	—1.1	51.8	43.0	
54	304	75 3	4 51	300	549	—0.8	52.2	42.5	
55	304	75 3	4 51	300	549	—0.8	52.3	45.1	
56	304	75 3	4 51	1735	3173	—1.5	52.4	43.9	
57	306	75 0	10 27	1334	2440	—1.3	52.0	40.5	
58	323	72 53.5	21 51	223	408	1.5	53.1	42.1	

No.	Stat. No.	Nordlig Bredde. (*North Latitude.*)	Længde fra Greenwich. (*Longitude from Greenwich.*)		Dybde hvorfra Prøven hentet. (*Depth from which the Samples were collected.*) Engelske Favne. (*English Fathoms.*)	Meter. (*Metres.*)	Temperatur. Celsius.	Neutralbunden Kulsyre. (*Carbonic Acid forming Carbonates.*) Mgr. per Litre.	Surtbunden Kulsyre. (*Carbon. Acid forming Bicarbonates.*) Mgr. per Litre.	Anmærkninger. (*Remarks.*)
59	335	76° 16'.5	14° 39'	E.	0	0	5.4	53.4	42.7	
60	347	76 40.5	7 47		1429	2613	—1.3	52.2	41.6	
61	347	76 40.5	7 47		0	0	4.4	52.6	41.0	
62	349	76 30	2 57		1487	2719	—1.5	51.6	43.5	
63	350	76 26	0 29	W.	0	0	3.0	54.0	47.2	
64	350	76 26	0 29		300	549	—1.1	53.2	45.8	
65	350	76 26	0 29		300	549	—1.1	53.3	46.0	
66	350	76 26	0 29		1686	3083	—1.5	51.9	43.9	
67	351	77 49.5	0 9		0	0	3.3	51.9	42.8	
68	352	77 56	3 29	E.	0	0	3.9	52.3	41.5	
69	352	77 56	3 29		300	549	—0.8	52.6	46.0	
70	355	78 0	8 32		0	0	4.9	52.4	43.2	
71	355	78 0	8 32		948	1734	—1.3	51.8	44.6	
72	361	79 8.5	5 28		0	0	4.2	52.4	42.7	
73	361	79 8.5	5 28		905	1655	—1.2	51.9	46.1	
74	362	79 59	5 40		0	0	5.2	52.6	43.2	
75	362	79 59	5 40		459	839	—1.0	51.8	44.6	
76	363	80 0	8 15		260	475	1.1	52.9	44.0	
77	368	78 43	8 20		315	567	1.6	52.9	42.4	
78	373	78 10	14 26		120	219	0.8	51.4	44.4	

Forsøgene ere nemlig ikke blevne udførte paa Vandprøverne strax efter deres Optagelse, men først, efterat de have henstaaet i kortere eller længere Tid. Angaaende Tidsrummet, hvori de enkelte Vandprøver have henstaaet før Bestemmelsen, kan anføres Følgende: No. 1, en Vandprøve, som Hr. Dampskibsfører E. Rostrup viste mig den Velvillie at skaffe mig, har kun henstaaet nogle Dage, de øvrige Prøver have henstaaet, No. 2—6 i ca. 2¼ Aar, 7—37 i ca. 1¼ Aar og 38—78 i 2 til 4 Maaneder paa et kjøligt Sted opbevarede paa Flasker, der vare forsynede med vel islebne Glasproppe. Der aabner sig altsaa en Mulighed for, at der ved Oxydation af de i Søvandet værende, aldrig manglende, organiske Bestanddele kunde have dannet sig en mindre Qvantitet Kulsyre paa Bekostning af den opløste Surstofmængde, en Proces, der naturligvis kun har Indflydelse paa den surt bundne Kulsyre, saafremt ikke Oxydationen skulde skride saa vidt frem, at ogsaa Surstoffet i Svovlsyren skulde medgaa til Dannelsen af Kulsyre, i hvilket Fald den dannede Kulsyre maatte træde ind som neutralbunden istedetfor den destruerede Mængde Svovlsyre. En saa vidt fremskreden Oxydation kan imidlertid ikke tænkes mulig, medmindre man til Prop i Flaskerne anvender Kork, da den i Søvandet opløste Surstofgas er mere end tilstrækkelig til at oxydere alle de oprindelig tilstedeværende organiske Bestanddele. Det kan ogsaa bemærkes, at det ikke i nogen af de undersøgte Vandprøver har været muligt at paavise det mindste Spor af Svovlvandstof. For saa nogenlunde at fixere de Mængder Kulsyre, som paa denne Maade skulde kunne dannes, har jeg anmodet min Ven Schmelck, som har været beskjæftiget med Undersøgelse af de faste Bestanddele i Vandet i det af Expeditionen befarede Hav, og som saaledes ogsaa har

having all of it been allowed to stand over for a longer or shorter period. With respect to the interval that had elapsed before commencing the determinations, the following particulars can be given: — No. 1, a sample of sea-water which Captain E. Rostrup had the kindness to procure me, did not stand over for more than a few days; of the remaining samples, Nos. 2—6 were preserved for about two years and a quarter, Nos. 7—37 for about one year and a quarter, and Nos. 38—78 from two to four months, all of them in a cool spot, and in bottles furnished with ground glass stoppers. Hence it is just possible that oxidation of the organic matter never absent in sea-water may have produced a small quantity of carbonic acid, by reducing the amount of oxygen, a process which of course could only affect the carbonic acid forming bicarbonates, unless indeed oxidation were so far advanced, that the oxygen in the sulphuric acid should also contribute to the formation of carbonic acid, in which case such carbonic acid would reimplace the sulphuric acid decomposed. But this advanced stage of oxidation is clearly impossible unless the bottles are *corked,* since the oxygen in sea-water is more than sufficient to oxidize all organic matter originally present. I can also observe, that in none of the samples of water examined was it possible to detect the slightest trace of sulphuretted hydrogen. With the object of determining approximately what proportion of carbonic acid could result from this process, I requested my friend Mr. Schmelck — whose labours have been chiefly confined to the examination of the solid matter present in the water of the seas explored on the Expedition, and who accordingly instituted a series of experiments to ascertain the amount of organic substances it contained — to furnish

udført en Række Forsøg til Bestemmelse af de organiske Stoffes Mængde, om at meddele mig de fornødne Data. Ifølge ham ere de organiske Stoffes Mængde kun underkastet meget smaa Variationer, og affarver 1 Litre Søvand gjennemsnitlig 3 Mgr. Kamæleon, som under Forudsætning af Reduction til Oxydulsalt kun kan afgive henimod 0.8 Mgr. Surstof, hvoraf det lettelig vil kunne indsees, at den dannede Mængde Kulsyre ikke kan være meget stor, naar Surstofforbruget selv ved en saa energisk Oxydation som ved Anvendelse af Kamæleon er saa lidet. Og hvad der især tyder paa, at den Oxydation, som kan foregaa ved Vandprøvens Henstand under ordinære Forholde, fuldstændig maa kunne negligeres, er den Omstændighed, at Schmelck har fundet Søvandets Evne til at affarve Kamæleon ligestor, hvadenten Vandprøven undersøges frisk eller først efter aarelang Henstand.

At noget af Kulsyren ved den lange Henstand skulde være fordampet, er der heller ingen Rimelighed for, naar man erindrer, at Søvandet er en alkalisk Vædske, som ikke indeholder det mindste Spor af fri Kulsyre, og som med saadan Kraft holder paa sin surt bundne Kulsyre, at den i timevis kan koges i det af Jacobsen angivne Luftudkogningsapparat med det Resultat, at kun en meget liden Brøkdel uddrives. Der er aabenbart større Fare for det Modsatte, nemlig at der skulde kunne absorberes noget af Atmosphærens Kulsyre, men for Undgaaelsen af denne Feilkilde er der sørget ved omhyggelig Opbevaring paa velproppede Flasker.

Resultaterne synes heller ikke at tyde paa, at Henstanden skulde have været til Skade for Vandprøvernes Brugbarhed, idet de alle uden Hensyn til den meget forskjellige Varighed af det Tidsrum, hvori de have henstaaet, vise nogenlunde det samme Resultat, og jeg tror saaledes ikke at tage meget Feil, naar jeg anser de af mig udførte Observationer som i alt Væsentligt ligesaa gode, som om de havde været udførte ombord paa friskt optagne Vandprøver.

Hvad angaar de af selve Methoden og Experimentationen flydende Observationsfeil, da vil de hyppigt udførte Controlbestemmelser kunne give de fornødne Bidrag til Bedømmelsen af deres Størrelse, saaledes er ved 13 Controlbestemmelser for den neutralt bundne Kulsyres Vedkommende den gjennemsnitlige halve Differents mellem 2 paa samme Vandprøve udførte Observationer bestemt til 0.11 Mgr. per Litre (Maximum 0.6) og for den surt bundne Kulsyres Vedkommende til 0.59 Mgr. per Litre (Maximum 1.35). Foruden den variable Feil vil der imidlertid i sidste Tilfælde ogsaa være en constant, idet det ikke lader sig undgaa, at man ved Arbeide i en kulsyreholdig Atmosphære vil erholde noget om end meget lidet for høie Resultater. Naar Feilene ved Bestemmelsen af den surt bundne Kulsyre er funden at være størst, da er Grunden dertil for en stor Del at søge deri, at man ved Retitration med Natronlud, især naar Rosolsyre anvendes som Index, erholder en meget skarp Endereaction, medens dette paa lang Vei ikke i samme Grad er Tilfælde, hvor Baryt re-

me with the necessary data. According to his observations, the amount of organic matter varies but very slightly, 1 litre of sea-water discolouring on an average 3^{mgr} permanganate of potash; and this quantity, assuming extreme reduction, cannot give off more than about 0.8^{mgr} of oxygen. Hence it is obvious that the amount of carbonic acid cannot be very large, considering the limited consumption of oxygen even with the use of permanganate of potash. But that the oxidation which can ordinarily result from allowing the water to stand over may be altogether ignored, is more particularly indicated by the fact of Schmelck having found the property in sea-water of discolouring permanganate of potash to be invariably the same, whether the samples are freshly drawn or have been preserved for years together.

Nor is there reason to assume, that any portion of the carbonic acid should have escaped by evaporation during the long interval, if we bear in mind that sea-water is an alkaline fluid, which does not contain the smallest trace of free carbonic acid, and which retains that present in bicarbonates with such vigour, that it may be boiled for hours together in the apparatus devised by Jacobsen for boiling out air and not part with more than a mere fraction. Nay, there is obviously danger of the reverse, viz. that some of the carbonic acid present in the atmosphere will be absorbed; but that source of error was effectually avoided by keeping the water in bottles provided with tight-fitting glass stoppers.

Judging, too, from the results, which were very nearly the same for all the samples, irrespective of the difference in the length of the period during which they had been preserved, the interval that had elapsed previous to examination did not appear to have had any injurious effect on the water for experimental purposes; and hence I feel tolerably convinced that my observations in all essential particulars are as reliable as if they had been conducted on board with freshly drawn water.

With respect to the errors of observation involved in the method itself, numerous test-determinations will serve as an approximate standard by which to compute their magnitude; thus, for instance, half the difference between two observations with the same sample of water was found, for the carbonic acid forming carbonates, to be 0.11^{mgr} per litre (maximum 0.6), and for the carbonic acid forming bicarbonates to be 0.59^{mgr} per litre (maximum 1.35). Exclusive of the variable error there will also, in the latter case, be a constant one, inasmuch as the results of experiments performed in an atmosphere containing carbonic acid must necessarily be somewhat, if but a very little, too high. When the error in the determination of the carbonic acid forming bicarbonates is found to be greatest, the reason will be chiefly this, that retitration with soda-lye, more especially if rosolic acid has been selected as the index, gives rise to a very decided terminal reaction, which does not result on the baryta water being titrated with oxalic acid; the reaction is then much less obvious. It must be likewise

titreres med Oxalsyre. Tillige bør det erindres, at de som Udtryk for den surt bundne Kulsyre opførte Tal indeholde Feilene saavel i Bestemmelsen af den neutralt bundne som den samlede Kulsyremængde.

Som man let vil overbevise sig om, vise de i Tabellen opførte Tal især for den neutralt bundne Kulsyres Vedkommende en mærkelig Overensstemmelse, naar nemlig 2 Observationer, begge udførte paa en Vandprøve hentet lige ved Grønlandsisen, undtages, ligger i alle de øvrige 63 Vandprøver den neutralt bundne Kulsyre mellem Grændserne 51.4 og 55.4 Mgr. per Litre, saaledes at den største Differents kun beløber sig til 4 Mgr., hvad der maa siges at være meget lidet i Betragtning af, at disse Tal ere fremkomne ved Undersøgelse af et Hav paa betydeligt over 200 geografiske Mile i Udstrækning saavel i syd og nord som øst og vest. Hvad derimod den surt bundne Kulsyre angaar, da ere de optrædende Differentser betydelig større og beløbe sig i Ydertilfældene til omkring 8 Mgr. pr. Litre.

Jeg har længe bestræbt mig for at opdage nogen Lovmæssighed i disse Variationer, uden at det dog saaledes som for Luftens Vedkommende har lykkes at erholde klare og paalidelige Resultater i saa Henseende og det ligegyldigt, hvadenten man vælger Dybdeforholdene eller den geografiske Beliggenhed til Udgangspunkt for sin Betragtning.

Da saaledes ingen Del af det undersøgte Felt udmærker sig fremfor den anden ved nogen tydelig Forskjellighed i Kulsyregehalt, og da de optrædende Differentser overalt ere smaa, ville de erholdte Resultater naturligst være at benytte til Udledning af Gjennemsnitsværdier, der kunne opføres som Udtryk for Kulsyregehalten i det undersøgte Hav i sin Helhed betragtet. De Gjennemsnitsværdier, som saaledes blive at opstille som Hovedresultater, ere for den neutralt bundne Kulsyres Vedkommende

$$52.78 \pm 0.083 \text{ Mgr. pr. Litre}$$

med en sandsynlig Afvigelse herfra af en enkelt Observation af $\pm$ 0.662 Mgr. pr. Litre
og for den surt bundne Kulsyres Vedkommende.

$$43.64 \pm 0.16 \text{ Mgr. pr. Litre}$$

med en sandsynlig Afvigelse herfra af en enkelt Observation af $\pm$ 1.26 Mgr. pr. Litre.

Da det først var bragt paa det Rene, at de af Dr. Jacobsen iagttagne Egenskaber hos Søvandet skrev sig derfra, at den i Søvandet existerende Saltblanding ved Koghede decomponerede neutrale Carbonater, maatte det ogsaa fremstille sig som en meget interessant Opgave at finde den nærmere Forklaring dertil.

Den nærmestliggende Tanke, som i denne Anledning først paatvang sig mig, var den at søge Grunden i Chlormagnesiumens bekjendte Egenskaber. At denne under Kogningen selv ved Tilstedeværelsen af Overskud af Chlornatrium skulde have Tilbøielighed til lidt efter lidt at spalte sig, og at der af den dannede Saltsyre skulde kunne uddrives noget Kulsyre, kunde jo ikke synes umuligt. Der

borne in mind, that the figures representing the carbonic acid forming bicarbonates also include the error in both titrations.

A glance at the Table will show that the figures therein set down, more particularly those representing the carbonic acid forming carbonates, exhibit a remarkable uniformity; save in 2 observations, both with a sample of water drawn in close proximity to the ice off the coast of Greenland, the carbonic acid forming carbonates determined in the remaining 63 samples lies between the limits 51.4^{mgr} and 55.4^{mgr} per litre and the greatest difference amounts therefore to only 4^{mgr}, which must be regarded as very small, considering that the said figures refer to the examination of water from a tract of ocean which, measured both from north to south and from east to west, extends for considerably more than 200 geographical miles. As regards the carbonic acid forming bicarbonates, the differences in the amounts determined are, however, much greater, reaching 8^{mgr} per litre.

I have long had my attention directed to the possible discovery of a law controlling these variations, similar to that which I found to regulate those of air, but have not yet succeeded in obtaining conclusive results; and it is quite immaterial whether depth or geographical position be made the basis of investigation.

The water in no part of the ocean-tract explored being characterised by properties plainly distinguishing it from that of any other, and the differences in the results obtained having invariably proved small, the latter will obviously serve for the computation of average formulæ representing the amount of carbonic acid present in the water of the sea investigated. These average formulæ, set down accordingly as the final results, were found to be —

$$52.78 \pm 0.083^{mgr} \text{ per litre}$$

for the carbonic acid forming carbonates, with a probable error in a single observation of $\pm$ 0.662 per litre; and

$$43.64 \pm 0.16^{mgr} \text{ per litre}$$

for the carbonic acid forming bicarbonates, with a probable error in a single observation of $\pm$ 1.26$^{mgr.}$ per litre.

Having now obtained conclusive proof that the properties observed by Dr. Jacobsen in sea-water were the result of the property possessed by the saline compounds present therein of decomposing at the boiling-point neutral carbonates, the next step was to find a satisfactory explanation of the interesting phenomenon.

My first thought in this direction was to seek the cause in the known properties of chloride of magnesia. Assuming this body to have a tendency of gradually decomposing during the process of boiling, carbonic acid might possibly be driven off by the hydrochloric acid formed. Against such an hypothesis, however, various objections may be raised, Dr. Jacobsen and others having shown that sea-

lader sig imidlertid reise Indvendinger mod denne Betragtningsmaade, idet det af Dr. Jacobsen med Flere er paavist, at Søvand lader sig inddampe til Tørhed og Saltene endog tørre ved en Temperatur af 180° C., uden at nogen synderlig Mængde Saltsyre forflygtiger sig, og det er i Virkeligheden heller ikke fornødent at ty til Chlormagnesiumens Dissociation for at finde den rimeligste Forklaringsgrund. Man behøver blot at holde sig til den kulsure Magnesia og dens Egenskaber, saaledes som de ere kjendte af Arbeider udførte af de mest berømte Chemikere.

Ifølge Angivelser af Berzelius,[1] H. Rose,[2] Fritzsche,[3] Nörgaard[4] og L. Joulin[5] er den ved høiere Temperatur dannede kulsure Magnesia altid mere eller mindre basisk, ja ifølge Berzelius og H. Rose er selv de ved Blanding af Magnesiaopløsninger med kulsure Alkalier i Kulden dannede Bundfald mere kulsyrefattige end mættet kulsur Magnesia. Der findes om den kulsure Magnesia et meget stort Antal tildels meget modstridende Angivelser, og der er, eftersom Fremstillingsmaaden er varieret, erholdt meget forskjelligt sammensatte Salte, hvis procentiske Sammensætning ifølge Analyserne stemme meget daarligt overensmed den af de opstillede Formler beregnede. Disse Forbindelser ere ogsaa af enkelte Forfattere betragtede som basiske Salte af variabel Sammensætning og ansees af L. Joulin endog for en Blanding af vexlende Mængder Oxyd og Carbonat. Det vilde føre for langt her at gjennemgaa de talrige over dette Emne forfattede Afhandlinger, og jeg skal derfor indskrænke mig til at henvise til Gmelin-Kraut's Handbuch der Chemie 6te Aufl. 2 432, hvor det Væsentligste findes i Uddrag. Det maa dog være mig tilladt at citere nogle Udtalelser af H. Rose, som jeg nylig blev opmærksom paa, Udtalelser, som vise at Videnskaben allerede meget længe har været i Besiddelse af Materiale til Forklaringen af de af Dr. Jacobsen gjorte Observationer. H. Rose siger (Pogg. Ann. [3] — 23 — 417) Følgende:

"Als das Gesetz der einfachen chemischen Proportionen aufgestellt und hinreichend durch Versuche bewiesen worden war, ergab sich die Neutralität zweier sich zersetzender Salzauflösungen als eine ganz natürliche Folge des Gesetzes der bestimmten Verhältnisse, in denen sich alle Körper, also auch Säuren und Basen, mit einander verbinden.

Aber das Gesetz, dass durch Zersetzung zweier neutraler Salze nach ihrer Auflösung in Wasser wiederum zwei neutrale Salze entstehen, ist nicht richtig, wenigstens nicht in der Allgemeinheit, wie es bisher ohne den geringsten Widerspruch angenommen worden ist.

Es ist bemerkenswerth, dass die so ausserordentlich vielen Ausnahmen, die bei diesem Gesetze stattfinden, nicht früher aufgefallen sind, obgleich mehrere derselben schon seit langer Zeit bekannt waren. Nur eine fast einzeln stehende

[1] Berzelius Jahresbericht 17 — 158.
[2] Pogg. Ann. 83 — 435.
[3] Pogg. Ann. 37 — 310.
[4] K. Danske Vid. Selsk. Skrift. [5] — 2 — 54 (1850).
[5] Ann. Chim. Phys. [4] — 30 — 271.

water admits of being evaporated to dryness, and the residue even dried at a temperature of 180° C. without volatilising any considerable quantity of hydrochloric acid. But it is not necessary to seek in the properties of chloride of magnesia the most plausible means of explanation; we need only keep to the carbonate and its properties, as determined by the most renowned Chemists.

According to the statements of Berzelius,[1] H. Rose,[2] Fritzsche,[3] Nörgaard,[4] and L. Joulin,[5] carbonate of magnesia formed at a high temperature invariably contains less carbonic acid than the neutral salt; nay, according to Berzelius and Rose the precipitate resulting from the mixture of carbonate of potash, when cold, with solutions of magnesia, contains less carbonic acid than saturated carbonate of magnesia. For carbonate of magnesia we have a very large number of conflicting statements, and the compounds obtained have been found to vary greatly with the mode of operation, the proportion of their constituents, too, often agreeing but very indifferently with that computed by the formulæ. By some authors these combinations have been regarded as basic salts, varying in their component parts; nay by L. Joulin, as consisting of inconstant mixtures of some oxide and carbonate. I lack space here to notice the numerous memoirs treating of this subject, and shall therefore merely refer the reader to Gmelin-Kraut's 'Handbuch der Chemie' (6te Auflage, 2, p. 432), in which copious extracts from them will be found. I cannot however refrain from quoting certain remarks by H. Rose, on which a short time since I happened to light, — remarks showing science to have been long in possession of materials amply sufficient to explain Dr. Jacobsen's observations. In Pogg. Ann., [3] 23, p. 417, H. Rose observes as follows: —

"Als das Gesetz der einfachen chemischen Proportionen aufgestellt und hinreichend durch Versuche bewiesen worden war, ergab sich die Neutralität zweier sich zersetzender Salzauflösungen als eine ganz natürliche Folge des Gesetzes der bestimmten Verhältnisse, in denen sich alle Körper, also auch Säuren und Basen, mit einander verbinden.

Aber das Gesetz, dass durch Zersetzung zweier neutraler Salze nach ihrer Auflösung in Wasser wiederum zwei neutrale Salze entstehen, ist nicht richtig, wenigstens nicht in der Allgemeinheit, wie es bisher ohne den geringsten Widerspruch angenommen worden ist.

Es ist bemerkenswerth, dass die so ausserordentlich vielen Ausnahmen, die bei diesem Gesetze stattfinden, nicht früher aufgefallen sind, obgleich mehrere derselben schon seit langer Zeit bekannt waren. Nur eine fast einzeln stehende

[1] Berzelius Jahresbericht, 17, p. 158.
[2] Pogg. Ann. 83, p. 435.
[3] Pogg. Ann. 37, p. 310.
[4] K. Danske Vid. Selsk.-Skrift [5] 2, p. 54 (1850).
[5] Ann. Chim. Phys. [4] 30, p. 271.

Ausnahme erregte vor längerer Zeit ein allgemeines Aufsehen. Als man fand, dass eine Auflösung von gewöhnlichem phosphorsaurem Natron, welche für sich geröthetes Lackmuspapier bläut, mit einer Auflösung von salpetersaurem Silberoxyd, welche das Lackmuspapier unverändert lässt, versetzt, einen Niederschlag von gelbem phosphorsaurem Silberoxyd und eine Flüssigkeit giebt, welche gebläutes Lackmuspapier röthet, konnte diese Erscheinung nicht früher genügend erklärt werden, als bis die interessanten Untersuchungen von Clarke, und die sinnreiche Deutung derselben durch Graham bekannt wurde.

Aber vor weit längerer Zeit schon hatte man Erscheinungen beobachtet, die eben so räthselhaft waren, als der beschriebene Fall. Man hatte schon oft bemerkt, dass aus der Auflösung eines neutralen kohlensauren Alkalis durch Zersetzung vermittelst einer Auflösung eines neutralen Salzes von Magnesia, von Zinkoxyd oder von einem andern ähnlich zusammengesetzten Metalloxyd Kohlensäuregas entwickelt werde, besonders wenn die Fällung des kohlensauren Oxyds in der Wärme geschieht, und eine grosse Reihe von Versuchen, die man besonders in neuerer Zeit angestellt hat, hat ergeben, dass die meisten der kohlensauren unlöslichen Salze, welche man durch Zersetzung neutraler Salzauflösungen erhält, nicht die entsprechende Zusammensetzung des kohlensauren Alkalis haben, das zu ihrer Erzeugung angewandt worden ist. Sie enthalten weniger Kohlensäure, aber obgleich die Untersuchungen oft von sehr bewährten Chemikern angestellt worden sind, so hat man ihre Zusammensetzung sehr wenig übereinstimmend gefunden."

H. Rose har ogsaa ved Forsøg, som han sammesteds beskriver, fundet, at varmt fældt basisk kulsur Magnesia indeholder mindre Kulsyre, naar den efter Fældningen koges nogen Tid, end naar den strax gjøres til Gjenstand for Analyse.

Det kan efter dette ikke være tvivlsomt, at den kulsure Magnesia ved høiere Temperaturer decomponeres og antager meget forskjellige Sammensætninger, eftersom den koges kortere eller længere Tid. Rigtignok er det ikke nogensteds ved de tidligere Forsøg paavist, at man paa denne Maade kan faa Magnesia fuldstændig befriet for Kulsyre, men man maa ogsaa her tage Hensyn til, at man ved de tidligere Forsøg visselig overalt har arbeidet med temmelig store Mængder Bundfald, der naturligvis ikke med samme Lethed som Smaaportioner vil kunne erholdes decomponerede.

Forat paavise, at smaa Mængder kulsur Magnesia ved Kogning lader sig omvandle til fuldstændig rent Oxyd, gik jeg frem paa følgende Maade. Af fuldstændig ren friskt udglødet Soda afveiedes 0.422 Gr. og opløstes i 100 CC. kulsyrefrit destilleret Vand, ligeledes tilberedtes en 13 % indeholdende Opløsning af almindelig ren svovlsur Magnesia, som i Forveien ved gjentagne Omkrystallisationer var befriet for alle Forurensninger. En Blanding af 15 CC. af Sodaopløsningen med 50 CC. af Bittersaltopløsningen fortyndet med noget over 1/4 Litre friskt udkogt endnu varmt Vand kogtes i en kulsyrefri Luftstrøm i Classens

Ausnahme erregte vor längerer Zeit ein allgemeines Aufsehen. Als man fand, dass eine Auflösung von gewöhnlichem phosphorsaurem Natron, welche für sich geröthetes Lackmuspapier bläut, mit einer Auflösung von salpetersaurem Silberoxyd, welche das Lackmuspapier unverändert lässt, versetzt, einen Niederschlag von gelbem phosphorsaurem Silberoxyd und eine Flüssigkeit giebt, welche gebläutes Lackmuspapier röthet, konnte diese Erscheinung nicht früher genügend erklärt werden, als bis die interessanten Untersuchungen von Clarke, und die sinnreiche Deutung derselben durch Graham bekannt wurde.

Aber vor weit längerer Zeit schon hatte man Erscheinungen beobachtet, die eben so räthselhaft waren, als der beschriebene Fall. Man hatte schon oft bemerkt, dass aus der Auflösung eines neutralen kohlensauren Alkalis durch Zersetzung vermittelst einer Auflösung eines neutralen Salzes von Magnesia, von Zinkoxyd oder von einem andern ähnlich zusammengesetzten Metalloxyd Kohlensäuregas entwickelt werde, besonders wenn die Fällung des kohlensauren Oxyds in der Wärme geschieht, und eine grosse Reihe von Versuchen, die man besonders in neuerer Zeit angestellt hat, hat ergeben, dass die meisten der kohlensauren unlöslichen Salze, welche man durch Zersetzung neutraler Salzauflösungen erhält, nicht die entsprechende Zusammensetzung des kohlensauren Alkalis haben, das zu ihrer Erzeugung angewandt worden ist. Sie enthalten weniger Kohlensäure, aber obgleich die Untersuchungen oft von sehr bewährten Chemikern angestellt worden sind, so hat man ihre Zusammensetzung sehr wenig übereinstimmend gefunden."

Moreover, H. Rose also found, by experiments which he has described in the same paper, that basic carbonate of magnesia, precipitated warm, contains less carbonic acid when boiled for some time after precipitation than when at once subjected to analysis.

From what has been stated above, carbonate of magnesia is evidently decomposed at a high temperature, and enters into a variety of very different combinations according to the duraton of the boiling-process. True, none of the earlier experiments have shown that all the carbonic acid present in magnesia can be expelled by this method; but those experiments were conducted, we must remember, with a comparatively large amount of precipitate, which necessarily proves less easy to decompose than do small quantities.

In order to show that small quantities of carbonate of magnesia may be transformed by boiling into pure oxide, I went to work as follows. In 100^{cc} of distilled water free from carbonic acid were dissolved 0.422^{gr} of freshly heated carbonate of soda; a solution was likewise prepared containing 13 per cent of ordinary sulphate of magnesia, which by repeated crystallization had been previously freed from all impurities. A mixture consisting of 15^{cc} of the solution of soda and 50^{cc} of a solution of Epsom salts diluted with a little more than 1/4 of a litre of freshly boiled water, still warm, was boiled in Classen's ap-

ponere neutrale Carbonater maa blive at tilskrive gradvise Omsætninger mellem de i Søvandet existerende kulsure Salte og Magnesiaforbindelserne, og de af Dr. Jacobsen hos Søvandet iagttagne Egenskaber maa derfor ogsaa i mere eller mindre Grad tilligge alle andre magnesiaholdige Mineralvande, eller naar man lægger Roses ovenciterede Udtalelser til Grund, alle Saltopløsninger, forsaavidt de foruden Alkalier og Jordalkalier tillige indeholder opløselige Salte af nogen af de svagere Baser, som med Kulsyren danner ubestandige Forbindelser. Denne Omstændighed vil saaledes uden videre stemple saa godt som alle de til Bestemmelse af Forholdet mellem den frie og bundne Kulsyre i Mineralvande anvendte talrige Methoder som mere og mindre upaalidelige ligeoverfor magnesiaholdige Mineralvande, idet man ved dem til Bestemmelse af neutralbunden Kulsyre enten anvender Residuet fra Inddampning eller paa anden Maade benytter sig af Kogning, hvor den efter det forhen udviklede vil være utilladelig.

Det vil sluttelig ikke være paa urette Sted kortelig at berøre de Synsmaader, som fra ældre Tider har været gjort gjældende, hvad angaar de i Søvandet indeholdte Carbonater.

Efter de Fremgangsmaader, hvorved disse af ældre Forfattere ere bestemte, kunde de naturligvis kun erholdes udskilte i Form af kulsur Kalk eller, som af enkelte ogsaa fundet, lidt kulsur Magnesia, men deraf følger ingenlunde, at de med Nødvendighed oprindelig skulde forekommet i Søvandet under denne Form, ja dette er saa langt fra sikkert, at jeg meget mere skulde være tilbøielig til at tro, at saa ikke er Tilfælde. Koger man nemlig Søvand i det af Dr. Jacobsen beskrevne Luftudkogningsapparat, undviger der, som allerede før bemærket, meget smaa Qvantiteter Kulsyre, idet man kan fortsætte Kogningen med vexlende Afkjøling en hel Time uden at faa uddrevet mere end en Brøkdel af Milligram pr. Litre. Kogepunctet vil her i Begyndelsen ligge meget lavt, men stiger, efterhaanden som den undvigende Luft og den dannede Vanddamp forøger Trykket, meget hurtigt, saaledes at jeg allerede under den første Halvdel af Operationen har observeret en Temperatur af 89° C. Naar saaledes de i Søvandet indeholdte sure Carbonater vise en saa haardnakket Modstand mod Decomposition, at de i en hel Time skulde saa godt som aldeles uden Virkning kunne udsættes for en Temperatur af omkring 90° C., da synes mig denne Egenskab at passe noget bedre paa surt kulsurt Natron end paa sur kulsur Kalk, og det vilde desuden falde vanskeligt at forklare Søvandets tydelige alkaliske Reaction, medmindre man kunde antage, at Carbonaterne i det Mindste for en ikke ringe Del bestod af Alkalisalte.

Med Hensyn paa Qvantiteten af de i Søvandet forekommende kulsure Salte, da stemme de derover existerende Opgaver meget daarligt overens, de lyde i Regelen paa Spor undertiden endog paa Intet, medens der af enkelte igjen er opført forholdsvis store Mængder. Saaledes finder

decomposing when boiled neutral carbonates, arises from the slow reciprocal action of the carbonates and salts of magnesia it contains, and the properties observed by Dr. Jacobsen in sea-water must therefore to a greater or less extent distinguish all mineral waters containing magnesia compounds, or, according to Rose, in his statements quoted above, all solutions of salts, provided they contain, exclusive of sodium, potassium, lime, barium, and strontium, also soluble salts of some one of the weaker bases, which along with carbonic acid form inconstant combinations. Hence, this circumstance clearly shows, that of the numerous methods devised for determining, in mineral waters, the relative proportion of free carbonic acid and that present in carbonates nearly all are, when magnesia is present, unreliable, since for the determination of the carbonic acid present in carbonates, either the residue from evaporation or some other result of boiling is had recourse to, which has been shown to be inadmissible.

Finally, it will not be out of place to notice the views originally entertained with regard to the carbonates present in sea-water.

By the process according to which the earlier chemists determined these compounds, they could of course obtain them only in the form of carbonate of lime, or, as found by some observers, along with a little carbonate of magnesia; but from this it does not by any means follow that they necessarily occur in that form in sea-water; nay, I am myself inclined to believe that such is not the case. On boiling sea-water in the apparatus described by Dr. Jacobsen, very small quantities only of carbonic acid are found to escape; the fluid may be alternately boiled and cooled for an hour together without liberating more than a fraction of a milligramme per litre. The boiling-point with this method will at first be very low, but, on the pressure being increased by the escape of the air and the formation of steam, rapidly rise; even in the first half of the operation I have observed a temperature of 89° C. The vigorous resistance to decomposition thus exhibited by the bicarbonates in sea-water, which admits of their being exposed almost without effect for an hour together to a temperature of nearly 90° C., would rather seem to indicate bicarbonate of soda than bicarbonate of lime; and besides, the decided alkaline reaction of sea-water would be difficult to explain unless by assuming the carbonates — or a considerable portion of them at least — to consist of carbonate of soda and potash.

With regard to the proportion of carbonates present in sea-water, the results as yet obtained agree but very indifferently; the majority of observers have detected traces only or none whatever, whereas some allege to have found comparatively large quantities, as will be seen from the following Table.

von Bibra[1] Intet,
Robinet og Lefort[2] i det røde Hav Spor,
Pisani[3] ved Bujuk-Déré i Bosporus 0.1569 Gr. pr. Litre,
C. Knauss[4] 0.011 Gr. pr. Litre,
Thorpe og Morton[5] i det irske Hav 0.04754 i 1000 Dele Vand,
Dr. Jacobsen i Nordsøen 0.018—0.028 Gr. pr. Litre,
Vierthaler[6] i Adriaterhavet 0.315 Gr. pr. Litre,
F. Wibel[7] i det joniske Hav Intet
og Buchanan[8] i de sydlige Have enten Intet eller og meget smaa Mængder.

Saa store Forskjelligheder vilde naturligvis være meget paafaldende, i Fald man kunde anse Resultaterne af disse Observationer for aldeles correcte, hvad der imidlertid ikke er muligt, da alle uden Undtagelse ere udførte efter Methoder, som kun for aldeles specielle Sammensætninger af Havvandet kunde føre til nogenlunde rigtige Resultater.

Ved de tidligere i denne Afhandling beskrevne Forsøg er det godtgjort, at Søvandet (under enhver Omstændighed det af Forfatteren undersøgte) ved Kogning i kulsyrefri Luft taber al neutralbunden Kulsyre, og det maa endvidere ved de af v. Bibra og Buchanan udførte Observationer ansees fuldt bevist, at almindeligt Oceanvand ved Inddampning til Tørhed selv i en kulsyreholdig Atmosphære undertiden kan give et fuldstændig kulsyrefrit Residuum, medens det kanske ligesaa ofte ikke vil være Tilfælde, idet der ofte af Buchanan og altid af Jacobsen er fundet Carbonater i Residuet. Hvor den neutralbundne Kulsyre under Inddampningen bortdrives, vil der til Gjengjæld altid udfældes den æqvivalente Mængde Magnesia, som, naar Residuet henstaar i kulsyreholdig Luft før Bestemmelsen, vil kunne gjenoptage en Del Kulsyre, og det er derfor let forklarligt, at man ved Anvendelse af Inddampning vil kunne erholde meget forskjellige Resultater selv i Søvand af fuldstændig identisk Sammensætning.

En til Bestemmelse af Carbonaterne hyppig anvendt Methode er den, hvorefter Søvandet koges i ca. 1 Time under stadig Fornyelse af det fordunstede Vand, hvorefter det udskilte Bundfald frafiltreres og veies, saaledes som Vierthaler og flere har gjort, medens T. E. Thorpe og E. H. Morton af den i Søvandet oprindelig indeholdte Kalkmængde og den i Vædsken efter Frafiltration af det ved Kogningen udskilte Bundfald tilbageværende beregner den kulsure Kalks Mængde.

---

[1] Ann. Chem. Pharm. 77 — 90.
[2] Compt. rend. 62 — 436.
[3] Compt. rend. 41 — 532.
[4] Petersb. Acad. Bull. 2 — 203 (1860).
[5] Ann. Chem. Pharm. 158 — 122.
[6] Wien. Acad. Ber. [2] — 56 — 479.
[7] Ber. Berl. chem. Ges. 6 — 184.
[8] Proc. Roy. Soc. 24 — 604.

Von Bibra:[1] none.
Robinet and Lefort,[2] in the Red Sea: traces.
Pisani,[3] near Bujuk-Déré in the Bosporus: 0.1569^{gr} per litre.
C. Knauss:[4] 0.011^{gr} per litre.
Thorpe and Morton,[5] in the Irish Sea: 0.04754 in 1000 parts of water.
Dr. Jacobsen, in the North Sea: 0.018—0.028^{gr} per litre.
Vierthaler,[6] in the Adriatic Sea: 0.315^{gr} per litre.
F. Wibel,[7] in the Ionian Sea: none.
Buchanan,[8] in the Southern Seas: none at all or traces only.

Differences so considerable would indeed be extraordinary, assuming the results of the observations to be quite correct; this, however, is simply impossible, since they were all without exception obtained by methods none of which, save for sea-water of a particular composition, can lead to results even approximately reliable.

By the experiments previously described in this Memoir, it has been shown that sea-water — at least that examined by the author — can, by boiling in an atmosphere free from carbonic acid, be made to part with all of its carbonic acid that is present in carbonates; and moreover, the observations of v. Bibra and Buchanan have furnished conclusive proof, that ordinary ocean-water when evaporated to dryness even in a atmosphere containing carbonic acid, sometimes gives a residue in which no trace of carbonic acid can be detected, but the reverse will, perhaps, no less frequently prove to be the case, seeing that Buchanan has often, and Jacobsen always, found carbonates present in the residue. When the neutral carbonates are decomposed during the process of evaporation, an equivalent proportion of magnesia will invariably be precipitated, which, on the residue being allowed to stand over previous to determination in an atmosphere containing carbonic acid, may possibly absorb some carbonic acid; and hence, when recourse is had to evaporation, very different results may obviously be obtained even with water identical in composition.

A method frequently adopted for determining the proportion of carbonates, is to boil the sea-water for about an hour, while steadily adding freshwater in place of that evaporated, after which the precipitate is filtered off and weighed, as done by Vierthaler and others; T. E. Thorpe and E. H. Morton calculate the proportion of carbonate of lime by comparing the amount of lime originally present in the water with that contained in the fluid after filtering off the precipitate.

---

[1] Ann. Chem. Pharm. 77, p. 90.
[2] Comp. rend. 62, p. 436.
[3] Comp. rend. 41, p. 532.
[4] Petersb. Acad. Bull. 2, p. 203 (1860).
[5] Ann. Chem. Pharm. 158, p. 122.
[6] Wien. Acad. Ber. [2] 56, p. 479.
[7] Ber. Berl. chem. Ges. 6, p. 184.
[8] Proc. Roy. Soc. 24, p. 604.

Det er af samme Grund som ovenfor klart, at denne Fremgangsmaade for almindeligt Oceanvands Vedkommende vil føre til aldeles værdiløse Resultater, uden at det dog med Sikkerhed kan paastaaes, at dette i samme Udstrækning skulde være Tilfælde for det af Vierthaler undersøgte Vand, som har en fra almindeligt Søvand meget forskjellig Sammensætning. Efter de talrige og værdifulde Analyser af Søvand, som vi skylde Professor Forchhammer, indeholder Vandet i de store Verdenshave uden synderlig store Variationer i de enkelte Bestanddeles indbyrdes Forhold gjennemsnitlig

Chlor + Brom	1.895 %
Svovlsyre (SO_3)	0.225 -
Magnesia	0.210 -
Kalk	0.056 -

medens Vierthaler i Adriaterhavet har fundet

Chlor + Brom	2.264 %
Svovlsyre	0.262 -
Magnesia	0.237 -
Kalk	0.371 -

Denne uforholdsmæssig store Forøgelse af Kalkmængden uden tilsvarende Forøgelse af Svovlsyremængden vil bidrage til, at det af Vierthaler undersøgte Vand vil have en meget større Tilbøielighed til ved Kogning at udskille kulsur Kalk, hvad der i ikke ringe Grad kan tænkes at forrykke de almindelige Phænomener.

Hvad angaar de af Thorpe og Morton udførte Observationer, da er der i en Henseende en væsentlig Forskjel mellem de af disse Forfattere og de af mig erholdte Resultater. Jeg havde, allerede før jeg blev opmærksom paa den af dem offentliggjorte Afhandling, lagt Mærke til, at der af Søvand ved Kogning i en kulsyrefri Luftstrøm i Classens Apparat udfældtes et Bundfald af Magnesia, indeholdende lidt fra Glasset hidrørende Kiselsyre, men jeg havde aldrig deri kunnet paavise hverken Kulsyre eller Kalk og det, uanseet om Kogningen afbrødes paa et tidligere eller senere Stadium, hvadenten den neutralbundne Kulsyre var helt eller kun delvis bortdrevet. Rigtignok anfører Thorpe og Morton intetsteds udtrykkelig, at de have undersøgt det udskilte Bundfald paa Kalk, men det fremgaar indirecte med stor Bestemthed, af hvad der forresten er bemærket, at saa maa have været Tilfælde.

At Vierthaler kunde faa udfældt kulsur Kalk af et saa abnormt sammensat Søvand som det i Adriaterhavet flydende, kunde ikke vække Forundring, men at det samme fandtes at være Tilfælde med Vandet i det irske Hav, som ved livlige Strømme stadig optager friske Vandmængder fra det store Verdenshav, og som i sin Sammensætning viser sig saa analogt det af den norske Nordhavsexpedition undersøgte, forekom mig meget paafaldende. Jeg har derfor gjentaget Thorpe og Mortons Forsøg aldeles uforandrede paa flere af de fra den norske Expedition hjembragte Vandprøver, men erholdt altid det samme Resultat, at det i det udskilte Bundfald trods al anvendt Møie ikke lykkedes at paavise Spor hverken af Kulsyre eller Kalk. Af det forhen Udviklede vil det fremgaa, at man af de ældre Angi-

For the same reason, as explained above, the said process with ordinary ocean-water will give results absolutely worthless; this cannot however be affirmed with certainty of Vierthaler's observations, the water he examined having been very different in composition from ordinary sea-water. According to the numerous and valuable analyses of sea-water for which we are indebted to Professor Forchhammer, the water of the great oceans, the component parts of which vary but little in their relative proportion, is generally found to contain —

Chlorine + Bromine	1.895 per cent.
Sulphuric Acid (SO_3)	0.225 - —
Magnesia	0.210 - —
Lime	0.056 - —

whereas the water of the Adriatic Sea, according to Vierthaler's observations, contains —

Chlorine + Bromine	2.264 per cent.
Sulphuric Acid	0.262 - —
Magnesia	0.237 - —
Lime	0.371 - —

This disproportionately large amount of lime without a corresponding increase in the amount of sulphuric acid will give the water examined by Vierthaler a tendency, when boiled, to precipitate carbonate of lime, which must to a considerable extent have a disturbing influence on the phenomena.

With regard to the series of observations instituted by Thorpe and Morton, there is, in one respect, an essential difference between their results and mine. Previous to my reading their Memoir, I had become aware of the fact, that, on boiling sea-water exposed to a current of air free from carbonic acid in Classen's apparatus, there results a precipitate of magnesia, containing a little silicic acid, derived from the glass; but I have never succeeded in detecting therein the presence of carbonic acid or lime: the result is precisely the same whether the boiling be interrupted at an early or a late stage of the process, or whether all or part only of the carbonates be decomposed. True, Thorpe and Morton nowhere distinctly state their having examined the precipitate for lime; but from what is observed in other respects, this must obviously have been the case.

That Vierthaler should have succeeded in precipitating carbonate of lime from water so exceptionally composed as is that of the Adriatic Sea, cannot surprise us; but that the same result should have been obtained with water from the Irish Sea, which by reason of rapid currents is continually receiving a large influx of water from the Atlantic Ocean, and which in its composition exhibits so great an analogy with that examined on the Norwegian North-Atlantic Expedition, does, to me, indeed appear strange. I have therefore repeated the experiments instituted by Thorpe and Morton, adopting their method without the slightest modification; but the results obtained were invariably the same: even with the most delicate tests I failed to detect the smallest traces of carbonic acid or

velser Intet med Bestemthed kan slutte om Carbonaternes Mængde i de store Verdenshave. Det synes dog, som om de af Buchanan udførte Bestemmelser af Kulsyren i Atlanterhavet, (hvorved han inddamper efter forudgaaende Tilsætning af Chlorbarium og tilslut med stærk Saltsyre forgjæves har bestræbt sig for at paavise Kulsyre i Residuet), med Sikkerhed skulde fastsætte en øvre Grændse for den tilstedeværende Carbonatmængde, men dette er i Virkeligheden ikke Tilfælde.

Som bekjendt beskytter uopløselige Sulfater Carbonater mod Decomposition endog, naar til Uddrivelse af Kulsyren anvendes saa radicale Midler som concentreret Svovlsyre, saaledes at man endog af den Grund har fundet det fornødent at modificere den af Fresenius og Will angivne Methode til Bestemmelse af Kulsyren i neutrale Carbonater.[1] De af Buchanan foretagne Undersøgelser efter Kulsyre i Residuet kan derfor ikke betragtes som Bevis for, at den ikke skulde have været tilstede, og det fremgaar ogsaa tydeligt af hans egne Udtalelser, at han selv har været af samme Mening.

Forat faa Rede paa, hvorvidt en ved Kogning bevirket Decomposition af de i Søvandet indeholdte neutrale Carbonater foregaar i større Udstrækning ogsaa, naar der i Vædsken findes uopløselige Sulfater, har jeg udført nogle Forsøg efter den af Buchanan foreslaaede Fremgangsmaade. Af nogle Vandprøver, som, undersøgte efter den af mig benyttede Methode, viste sig at indeholde en Sum af surt- og neutralbunden Kulsyre af 96 Mgr. pr. Litre og derover, erholdtes ved Inddampning til Tørhed efter Tilsætning af Chlorbarium uddrevet kun henimod 50 Mgr., ved én enkelt Undtagelse erholdtes engang over 50 Mgr. pr. Litre. Det vil sige, den uddrevne Kulsyremængde var ikke synderlig høiere end den af Buchanan for Vandet i Æqvatoregnene angivne og beløb sig til kun faa Mgr. over, hvad den surtbundne Kulsyre efter paalidelige Observationer skulde beløbe sig til, de endnu i Residuet tilbageværende Carbonater lykkedes det heller ikke mig at paavise.

Spørgsmaalet om Carbonaternes Mængde i de sydlige Have maa derfor endnu betragtes som aabent.

Forhaabentlig resterer endnu en Del af de fra Challengerexpeditionens Togter hjembragte Vandprøver, og man vil i saa Fald ved Undersøgelse af disse kunne give Bidrag til Besvarelsen af disse Spørgsmaal.

Efterat Ovenstaaende var nedskrevet paa Norsk, men førend det endnu var oversat paa Tysk, ankom hertil 2det og 3die Hefte for 1879 af Fresenius' Zeitschrift für anal. Chem., hvori E. Bohlig offentliggjør en Afhandling,[2] hvoraf det sees, at han ved Arbeide med naturlige Mineralvande har observeret Omsætninger mellem kulsur Kalk og svovl-

[1] Fresenius, Qvant. Analyse, 5te Aufl. 364 bb.
[2] Fresenius' Zeitschrift, 18 — 195.

of lime. From what has been already explained, it is obvious that nothing definite can be inferred from earlier statements respecting the proportion of carbonates in the water of the great oceans. The carbonic acid determinations performed by Buchanan with water from the Atlantic Ocean (he had recourse to evaporation, adding first chloride of barium, and then attempting, unsuccessfully, to detect carbonic acid in the residue by means of strong hydrochloric acid) would appear to fix a limit for the maximum amount of carbonates contained in sea-water; but such is not really the case.

The presence of insoluble sulphates serving, as is known, to protect carbonates against decomposition, even when concentrated sulphuric acid is made use of to expel the carbonic acid, it was necessary for this reason alone to modify the process devised by Fresenius and Will for determining carbonic acid in neutral carbonates.[1] Hence, the experiments performed by Buchanan with a view to detect carbonic acid in the residue, cannot be regarded as affording conclusive proof of its absence; indeed, he himself, as appears from his statements, is clearly of the same opinion.

In order to ascertain whether the decomposition by boiling of the neutral carbonates in sea-water also took place to a considerable extent when insoluble sulphates were present in that fluid, I made a few experiments by Buchanan's process. From several samples of sea-water which, examined by the method I adopted, were found to contain 96^{mgr} of carbonic acid per litre, I succeeded, by evaporation to dryness, after adding a solution of chloride of barium, in liberating about 50^{mgr} only, with a solitary exception, when the amount exceeded 50^{mgr} per litre. The proportion of carbonic acid expelled was accordingly not much greater than that determined by Buchanan in water from the Equatorial Seas, and but a few millegrammes in excess of what the carbonic acid forming bicarbonates, according to trustworthy observations, should have been; of the carbonates said to be still present in the residue, I failed to detect any trace.

The amount of the carbonates contained in the water of the Southern Seas must, therefore, be still regarded as an open question.

It is to be hoped, that some of the samples of water collected on the 'Challenger' Expedition still remain, in which case their examination will serve to throw further light on the subject.

After this Memoir had been written in Norwegian, but previous to its translation into German, the 2nd and 3rd Parts of Fresenius' Zeitschrift für anal. Chemie for 1879 came to hand, in which E. Bohlig has published a paper[2] on transformations, observed by him in mineral waters, resulting from the reciprocal action of carbonate of

[1] Fresenius, Qvant. Analyse, 5te Aufl. 364, bb.
[2] Fresenius' Zeitschrift, 18, p. 195.

sur Magnesia, som fuldstændig svare til, hvad jeg efter de foran beskrevne Observationer har fundet for Søvands Vedkommende. Disse Omsætninger kunne saaledes, idet de ere iagttagne af to af hinanden uafhængigt arbeidende Chemikere, uden videre Begrundelse antages fuldstændig factiske.

Det vil af dette Bohligs Arbeide sees, at han allerede Sommeren 1878 over det samme Thema har publiceret en Afhandling,[1] som jeg ikke tidligere har været opmærksom paa. Den vilde dog ikke havt nogen væsentlig Indflydelse paa mine Undersøgelser, saasom de vigtigste af de Observationer, der har ført mig frem til de samme Resultater, som Bohlig først har beskrevet, allerede vare udførte 3—4 Maaneder, førend hans første Afhandling forelaa trykket.

[1] Fresenius' Zeitschrift, 17 — 301.

lime and sulphate of magnesia, which precisely agree with those I have described as occurring in sea-water. These transformations having accordingly been observed by two chemists working independently of each other, may without further proof be accepted as facts.

From the said paper, it appears that Bohlig published a treatise on the same subject in the summer of 1878,[1] to which my attention had not previously been directed. It would not, however, have materially influenced my experiments, the most important of the observations that led me to the results which Bohlig was the first to describe, having been instituted 3 or 4 months before his first treatise had left the press.

[1] Fresenius' Zeitschrift, 17, p. 301.

III. Om Saltholdigheden af Vandet i det norske Nordhav.

Hvor det gjælder at tilveiebringe Oplysninger om Variationerne af Saltmængderne i Havvandet, kan man til sine Saltbestemmelser benytte flere forskjellige Methoder, som hver især tidligere har fundet udstrakt Anvendelse. Den nærmest liggende af disse bestaar i Vandets Afdampning og derpaa følgende Tørring og Veining af de som Residuum tilbageblivende Salte, en Fremgangsmaade, som rigtignok directe fører til Maalet, men som til Gjengjæld ogsaa fordrer temmelig meget Arbeide. Som mere indirecte men ogsaa ulige mindre besværlige Methoder kan ogsaa anvendes Bestemmelse af Havvandets Chlormængde[1] eller Egenvægt, hvoraf man gjennem passende bestemte Coefficienter kan beregne den samlede Saltmængde, forudsat, at man kan antage et constant indbyrdes Forhold mellem de i Søvandet indeholdte faste Bestanddele. Den første af disse Methoder medfører foruden Besværligheder ved Udførelsen ogsaa den Ulempe, at den ikke lader sig anvende ombord paa et Fartøi i aaben Sø, hvor Skibets Bevægelser forbyder Brugen af Vægt, medens Egenvægtsbestemmelser ved Hjælp af Aræometre og volumetriske Chlorbestemmelser meget letvindt og med temmelig stor Nøiagtighed kan udføres ombord selv i temmelig uroligt Veir.

Hvor man derfor ikke tror sig sikker paa at kunne opbevare Vandprøverne i længere Tidsrum uden derved at risikere, at de undergaa Forandringer, som kunde ytre en skadelig Indflydelse paa Resultaterne af de erholdte Saltbestemmelser og, hvor man som Følge deraf maa lægge Hovedvægten paa en hurtig Undersøgelse af Vandprøverne i frisk Tilstand, bliver man saaledes udelukkende henvist til Brugen af Chlorbestemmelser eller Egenvægtsbestemmelser som Maal for den samlede Saltgehalt.

Paa det første af den norske Expeditions Togter blev af Svendsen, hvem de chemiske Observationer dengang vare

[1] Saavel her som overalt senere forstaaes ved Chlormængde den samlede Chlor- og Brommængde.

III. On the Amount of Salt in the Water of the Norwegian Sea.

When seeking to investigate the degree in which the proportion of salt varies in sea-water, choice may be made for performing the salt-determinations between several methods, each of which has in turn been extensively adopted. The most simple process, is first to evaporate the water, and then dry and weigh the salts left in the residue, a mode of operation which, though leading direct to the desired result, involves considerable labour. Two other methods, not so direct, but far less tedious, consist in determining either the specific gravity of the water or the amount of chlorine[1] it contains, from which, by means of proper coefficients, the total amount of salt may be computed, provided always that a constant proportion can be assumed to exist between the solid constituents of sea-water. The first process is attended, irrespective of the troublesome mode of operation, with another drawback, viz. the impractibility of adopting it on board ship in the open sea, where the motion of the vessel altogether precludes the use of the balance, whereas both specific gravity determinations, with the hydrometer, and volumetric determinations of chlorine, may be performed at sea with the greatest ease, and very considerable accuracy, even in comparatively rough weather.

Hence, when there is reason to fear that the samples of water cannot be preserved for any length of time without exposing them to chemical change, which might exert a disturbing influence on the results; and whenever, accordingly, weight must be chiefly attached to their immediate examination, the only practicable standard of measurement for computing the total amount of salt will be that furnished by determinations of chlorine or of specific gravity.

On the first voyage of the Norwegian Expedition, Svendsen, who then, as previously stated, did the chemical

[1] By "the amount of chlorine," here and elsewhere throughout this Memoir, is understood the total amount of chlorine and bromine.

overdragne, til Undersøgelser over Saltgehalten udelukkende anvendt Egenvægtsbestemmelser, hvorimod jeg paa de to sidste Togter ved Siden af disse ogsaa har udført et større Antal Chlortitreringer for gjennem denne Control at give Resultaterne en større Sikkerhed.

Til Undersøgelser over den i Søvandet indeholdte Chlormængde medhavdes paa de to sidste Togter foruden Sølvopløsning af saadan Styrke, at 1 CC. af denne omtrent svarede til 1 CC. Søvand, ogsaa 2 paa første Togt indsamlede Vandprøver, bestemte til som Normaler at tjene til den nøjagtigere Fastsættelse af Sølvopløsningens Styrke. Disse Normalers Chlormængde i Procenter blev ved omhyggeligt udførte Veiningsanalyser hvert Aar bestemt saavel før Expeditionens Udreise som efter dens Hjemkomst bestandig med meget nær det samme Resultat, hvorhos tillige deres Egenvægter ved Hjælp af Aræometret ombord aflæstes. Til Brug ved alle ombord udførte Chlortitreringer tjente kun to Büretter af lignende Construction og Størrelse, de samme, som af Stipendiat A. Helland anvendtes ved de Bestemmelser af Chlormængderne i Overfladevandet i Atlanterhavet, som denne foretog i Aaret 1875 paa en Reise til Grønland, de bleve af ham den Gang calibrerede ved Hjælp af Kviksølv og befundne særdeles tjenlige for Øiemedet.

Ved Bürretternes Brug fyldtes den ene med Sølvopløsning den anden med det til Undersøgelse bestemte Søvand, hvorefter en passende Portion Søvand fra den ene under Omrystning tilsattes Sølvopløsning fra den anden, indtil al Chlor var udfældt, idet chromsurt Kali tjente som Index. Begge Bürretters Stand aflæstes nu, og nogle Draaber Søvand tilsattes atter til Affarvning, hvorefter paany fulgte Tilsætning af Sølvopløsning og Aflæsning af Bürretternes Stand o. s. v. Gjennem en Række af 4 à 5 paa hinanden følgende lignende Aflæsninger erholdtes paa denne Maade de fornødne Data til Beregning af det Volum Søvand, som i hvert enkelt Tilfælde svarede til 1 CC. Sølvopløsning.

Paa denne Maade sammenlignedes paa den ene Side Søvandsprøverne og paa den anden Side ogsaa fra Tid til anden de medbragte Normaler med Sølvopløsningen, idet der altid sørgedes for, at Vandprøvernes og Opløsningernes Temperatur ikke fjernede sig synderlig meget fra hinanden. Bürretterne bleve for at tilveiebringe en bedst mulig Afløbning hyppig rensede med concentreret Svovlsyre.

Af de gjennem disse Observationer erholdte Tal er senere Søvandets Chlormængde beregnet efter følgende Formel

$$p = \frac{KSP}{ks}$$

hvori p betegner den undersøgte Vandprøves Chlormængde i Procenter, k det Antal CC. af samme, der svare til 1 CC. Sølvopløsning og s dens Egenvægt ved 17.°5 C., P Middeltallet mellem de før Udreisen og efter Hjemkomsten i Normalen fundne Chlormængder, K det Antal CC., som af denne svarer til 1 CC. Sølvopløsning og S dens Egen-

work, made exclusive use of specific gravity determinations: but for a considerable number of my own observations, on the last two cruises, I also adopted titration for chlorine as a means of testing the general accuracy of the results.

For estimating the amount of chlorine in sea-water, I took with me, on the two last cruises, besides a solution of silver of such strength that 1^{cc} of the fluid about corresponded to 1^{cc} of sea-water, also 2 samples of water collected on the first voyage, to serve as a normal standard by which to determine the strength of the solution of silver. Each year, both previous to the departure of the Expedition and after its return, the chlorine in these standard samples was carefully determined by weighing, and the percentage calculated accordingly, their specific gravity too, as shown by the areometer on board, having been likewise noted down. For all chlorine-titrations performed at sea, there were only two burettes in use, similar alike in size and construction, — those used by Mr. Helland for determining the amount of chlorine in the surface-water of the Atlantic on a voyage to Greenland in 1875; he had calibrated them by means of mercury, and they proved excellently adapted for the purpose.

When using the burettes, one was filled with solution of silver and the other with the sea-water selected for examination, after which solution of silver was added to a proper quantity of the sea-water, while shaking the flask in which the titration was performed till all chlorine had been precipitated, chromate of potassium serving as the index. The height of the fluid in both burettes was now read, and a few drops of sea-water added to the mixture, to discolour it, after which solution of silver was again added, and the height of the fluids read as before, &c. After the height had been thus read 4 or 5 times in succession, the necessary data were obtained for computing the volume of sea-water, which in each individual case corresponded to 1^{cc} solution of silver.

In this manner, were compared on the one hand the freshly drawn samples of sea-water, and on the other, from time to time, also the standard samples, with the solution of silver, care being taken to keep the samples of water and the solution as near as possible at the same temperature. In order to prevent any portion of the fluid from adhering to the burettes, they were frequently rinsed with concentrated sulphuric acid.

With the figures obtained from these observations, the amount of chlorine in sea-water was afterwards determined by the following formula —

$$p = \frac{KSP}{ks}$$

in which p signifies the percentage of chlorine in the sample of water examined, k the proportion in cubic centimetres representing 1^{cc} of the solution of silver, and s the specific gravity of the water at 17°5 C.; P the mean between the amounts of chlorine found in the standard sample before the departure and after the return of the

vægt ved 17° 5 C. Disse Observationer bleve dog selv paa de to sidste Togter ikke anstillede i samme Udstrækning som Egenvægtsbestemmelserne, der ogsaa oprindelig vare bestemte til i første Række at tjene som Maal for den samlede Saltgehalt.

Expeditionen var for Egenvægtsbestemmelser forsynet med flere Sæt Glasaræometre fra Dr. Küchler i Ilmenau, indrettede til at vise Søvandets Egenvægt ved $\frac{17°\,5}{17°\,5}$[1], saaledes at et Sæt viste Egenvægter fra 1 til 1.007, et andet fra 1.006 til 1.013, et tredie fra 1.012 til 1.019, et fjerde fra 1.018 til 1.025 og et femte fra 1.024 til 1.031. Aræometrene vare inddelte i Delstreger af Værdi 0.0002, medens Afstanden mellem disse Delstreger paa Scalaen beløb sig til meget nær 1.5^{mm}, saaledes at man maatte kunne aflæse uden stor Feil det 5te Decimal. Under Aflæsningen af Vandprøvernes specifiske Vægt anbragtes disse i en i dobbelt Slingrebøile ophængt Glascylinder, hvis indre Diameter beløb sig til omtrent det tredobbelte af Aræometrets Corpus, hvorefter dette omhyggeligt renset og aftørret neddykkedes i Vædsken og tillodes at svømme frit i nogen Tid, indtil det havde antaget Vandets Temperatur. Aflæsningen foretoges nu langs den undre Rand af Vædskens Niveau, idet samtidig Vandets Temperatur iagttoges paa et controlleret Thermometer, inddelt i Delstreger af Værdi 0.° 2.

Paa Grund af det af Expeditionen benyttede Dampskibs fortrinlige Egenskaber som Søskib voldte disse Observationer i nogenlunde roligt Veir ingensomhelst Vanskeligheder, selv naar Kursen sattes ret mod Vinden, hvorimod Skibets Duvning i meget haardt Veir altid ytrede sig i mærkbare om end smaa Bevægelser hos Aræometret. Hvor Vandprøverne optoges i saa uroligt Veir, at Bestemmelsen paa Grund deraf kunde medføre forøget Usikkerhed, bleve de altid hensatte nogle Dage, indtil de kunde undersøges under mere gunstige Vilkaar.

Disse saaledes aflæste Egenvægter maa imidlertid i 2 Henseender forbedres, idet man paa den ene Side maa anvende passende Correctioner for at faa de ved meget forskjellige Temperaturer aflæste Egenvægter reducerede til den fælles Normaltemperatur 17.° 5, og paa den anden Side maa befrie dem for Aræometrenes constante Feil.

Hvad for det Første Correctionerne for Temperaturen angaar, da give de af flere Videnskabsmænd udførte Bestemmelser af Søvandets Volumforandring med Temperaturen Midlerne til at beregne disse, idet baade Hubbard[2], L. F.

[1] Naar her som ofte senere bruges Betegningsmaaden Egenvægt ved $\frac{t^0}{T^0}$, da menes dermed Egenvægt ved t^0 i Forhold til destilleret Vand af T^0 som Enhed. Alle Temperaturangivelser i denne Afhandling ere udtrykte i Grader Celsius.

[2] Maury's Sailing Directions 1858, — 1 — 237.

Expedition, K those amounts in cubic centimetres corresponding to 1^{cc} of the solution of silver, and S the specific gravity of the standard sample at 17° 5 C. These observations, however, were not instituted even on the two last voyages to the same extent as those based on determinations of specific gravity, the method by which, as originally agreed upon, the total amount of salt was to be chiefly computed.

For performing specific gravity determinations, the Expedition had been supplied by Dr. Küchler of Ilmenau with divers sets of glass areometers, adapted to show the specific gravity of sea-water at $\frac{17°\,5}{17°\,5}$[1], one set indicating specific gravities from 1 to 1.007, another from 1.006 to 1.013, a third from 1.012 to 1.019, a fourth from 1.018 to 1.025, and a fifth from 1.024 to 1.031. The areometers were graduated in degrees of 0.0002, the interspaces on the scale measuring however very nearly 1.5^{mm}; and hence you could read off with comparative accuracy to the fifth decimal. When about to read the specific gravity, the samples of water were poured into a glass cylinder suspended in gimbals, the inner diameter of the cylinder being triple that of the areometer, which, carefully wiped and dried, was immersed in the fluid and suffered to float freely for some time till of the same temperature as the water. The specific gravity was now read in the ordinary way, the temperature of the water, as shown by a tested thermometer graduated in fifths of a degree Centigrade, being simultaneously observed.

The steamer selected for the Expedition being an excellent sea-boat, these observations were attended with no difficulty whatever in moderately fair weather, even when steaming dead against the wind; pitching, however, was found to have a distinctly disturbing effect on the areometer, and therefore all samples of water drawn when it was in any way violent, so as to give reason for apprehending greater uncertainty in the determinations if performed at once, were stored for a few days, till the weather had improved.

These readings of specific gravity have, however, a twofold need of correction, arising on the one hand from the very different temperatures at which the specific gravities were read, involving the necessity of their reduction by proper corrections to the normal temperature 17° 5, and on the other, the constant error of the areometer, which has also to be eliminated.

As regards the corrections for temperature, these may be computed by the determinations performed by divers men of science of the extent to which the volume of sea-water varies with the temperature, Hubbard,[2] L. F.

[1] The expression, specific gravity at $\frac{t^0}{T^0}$, signifies specific gravity at t^0, with distilled water of T^0 as the unit of comparison. All statements of temperature in this Memoir are given in degrees Celsius.

[2] Maury's Sailing Directions, 1858, 1, p. 237.

Ekman[1] og Thorpe og Rücker[2] har givet meget fuldstændige Tabeller over Søvandets Volumina ved forskjellige Temperaturer, hvorhos tillige ogsaa Dr. Karsten[3] har opstillet en Correctionstabel, hvorefter man kan reducere de ved vilkaarlige Temperaturer aflæste Egenvægter til 17.°5. Sammenstiller man de Correctioner, som efter disse Iagttagelser kunne beregnes, erholder man imidlertid især for de lavere Temperaturer meget daarligt overensstemmende Værdier, idet der kan optræde Differenter, der endog kan overskride 0.0004, mellem de af Ekmann's og Hubbard's Observationer beregnede Correctioner, hersker der den største Overensstemmelse, men ogsaa her gaar Differentserne paa enkelte Puncter op til meget nær 0.0001. I Betragtning af disse tildels temmelig betydelige Uoverensstemmelser mellem de hidtil publicerede Undersøgelser af denne Art kunde det ikke findes ubeføiet endnu engang at gjenoptage Bestemmelserne af Søvandets Volumina ved forskjellige Temperaturer, og jeg besluttede mig derfor til gjennem egne Undersøgelser at forvisse mig om, hvilken af de opstillede Tabeller der bedst svarede til Udvidelsen af det i det norske Nordhav flydende Vand. Dels i dette Øjemed dels for at bestemme de benyttede Aræometres Correctioner og de Constanter, hvormed Chlorprocenterne og Decimalerne i Egenvægten maatte multipliceres for at give Saltmængden, har jeg anstillet Undersøgelser med følgende Vandprøver.

Station.	Bredde.		Længde fra Greenwich.		Dybde	
					Eng. Fvn.	Meter.
245	68°	21′	2°	5′ V.	0	0
247	68	5.5	2	24 Ø.	500	941
253	Skjærstadfjord.				0	0
254	67°	27′	13°	25′	0	0
284	73	1	12	58	0	0
300	73	10	3	22 V.	0	0
349	76	30	2	57 Ø.	1487	2719
362	79	59	5	40	0	0

hvilke jeg for Kortheds Skyld i den Orden, hvori de her findes opførte, vil betegne med I, II o. s. v. indtil VIII. Til Bestemmelse af Søvandets Udvidelse benyttede jeg et Sprengel's Pyknometer[4], forarbeidet af to Stykker meget tynde Glasrør af et og samme Rør med en indvendig Diameter af omtrent 13^{mm}. Rørene vare nedentil sammenloddede ved Hjælp af et snævert kort u-formig bøiet Glasrør og oventil paaloddede knæformig bøiede solide Capillarrør med meget fin Aabning. Ved Paalodningen af disse Glasrør blev der saa meget som muligt draget Omsorg for, at kun en liden Del af de videre Rør udsattes for Opvarmning over Blæselampen, forat ikke Apparatet derved skulde

[1] Kongl. Svenska Vetenskapsak. Handlingar 1870 — 1.
[2] Proc. Roy. Soc., 24 — 159.
[3] Tafeln zur Berechnung der Beobachtungen an den Küstenstationen u. s. w. Kiel 1874.
[4] Pogg. Ann. 150 — 459.

Ekman[1], and Thorpe and Rücker[2] having prepared comprehensive Tables to show the volume of sea-water at different temperatures; Dr. Karsten[3], too, has published a Table of Corrections by which specific gravities read at any temperature may be reduced to 17.°5. Meanwhile, on comparing together the corrections computed from these observations, the values obtained, more especially for low temperatures, are found to agree but very indifferently, the difference in some cases exceeding even 0.0004. The agreement is closest between the corrections computed from Ekman's and Hubbard's observations; but here, too, the difference for some temperatures amounts to very nearly 0.0001. Considering, therefore, the want of uniformity, in some cases very considerable, exhibited by such observations of this kind as had till then been made public, it could not be deemed superfluous to investigate anew by a further series of experiments the variation in volume which sea-water is found to undergo at different temperatures; and hence I determined on ascertaining from the results of my own observations which of the aforesaid Tables corresponded best with the expansion of the water in the Norwegian Sea. Partly with this object in view, and partly in order to determine the corrections for the areometers and the constants by which the percentages of chlorine and the decimals of specific gravity had to be multiplied when computing the amount of salt, I examined the following samples of water: —

Station.	Latitude.		Longitude from Greenw.		Depth	
					Eng. Fath.	Metres.
245	68°	21′	2°	5′ W.	0	0
247	68	5.5	2	24 E.	500	941
253	The Skjærstad Fjord.				0	0
254	67°	27′	13°	25′	0	0
284	73	1	12	58	0	0
300	73	10	3	22 W.	0	0
349	76	30	2	57 E.	1487	2719
362	79	59	5	40	0	0

which I will indicate, for the sake of brevity, by the Roman numbers from I to VIII, and in the order in which they are given here. For determining the expansion of the sea-water, I made use of Sprengel's pycnometer;[4] the instrument was constructed of two pieces of glass tubing, cut off from the same length, with an inner diameter of about 13^{mm}. These tubes were sealed together at their lower ends by means of a short, narrow glass tube, bent into the form of the letter U, and had strong knee-shaped capillary tubes sealed on to their upper extremities. When sealing on these glass tubes, the greatest care was taken to confine the heat from the glass-blower's lamp to as small a portion

[1] Kongl. Svenska Vetenskapsak. Handlingar 1870, 1.
[2] Proc. Roy. Soc., 24, p. 159.
[3] Tafeln zur Berechnung der Beobachtungen an den Küstenstationen u. s. w. Kiel 1874.
[4] Pogg. Ann. 150, p. 459.

antage en anden Udvidelsescoefficient end den, det anvendte Glasrør oprindelig havde. Pyknometret blev først omkring 4 Maaneder, efterat det var blæst, taget i Brug til de Forsøg, som her skulle beskrives, forat ikke den for alle Glasgjenstande eiendommelige Contraction gjennem de første Maaneder efter deres Blæsning skulde bidrage til i mærkelig Grad at forandre dets Volum under Observationernes Udførelse. Pyknometret benyttedes ved de første Forsøg uden nogen Sikkerhedskugle, men maatte senere, hvor det fyldtes ved lavere Temperaturer, forsynes med en saadan, indrettet til at trækkes ind over det videre Capillarrør. Apparatet uden Sikkerhedskugle vil jeg for Kortheds Skyld betegne som Pyknometer No. 1 og med Sikkerhedskugle som Pyknometer No. 2. Ved Hjælp af disse udførtes følgende Forsøg i den Orden, hvori de her findes opførte.

	Pyknometer med Indhold.	Vægt Gr.	I Luft af sp. Vægt.
1.	Pykn. No. 1 tomt	15.9222	0.001200
2.	— - 1 „	15.9223	0.001200
3.	— - 1 med rent Vand af 17.°5	44.3153	0.001200
4.	— - 1 „ „ „ „ 17.5	44.3156	0.001201
5.	— - 1 „ „ „ „ 17.5	44.3151	0.001201
6.	— - 1 „ III . . . . „ 17.5	44.8097	0.001201
7.	— - 1 „ III . . . . „ 17.5	44.8093	0.001201
8.	— - 1 „ VII . . . . „ 17.5	45.0742	0.001200
9.	— - 1 „ VII . . . . „ 17.5	45.0738	0.001200
10.	— - 2 tomt	18.5665	0.001194
11.	— - 2 med I . . . . af 0.°	47.7869	0.001198
12.	— - 2 „ I . . . . „ 0.	47.7873	0.001198
13.	— - 2 „ I . . . . „ 0.	47.7871	0.001199
14.	— - 2 „ I . . . . „ 17.°5	47.7249	0.001201
15.	— - 2 „ I . . . . „ 17.5	47.7246	0.001201
16.	— - 2 „ I . . . . „ 20.	47.7085	0.001198
17.	— - 2 „ I . . . . „ 20.	47.7087	0.001198
18.	— - 2 „ I . . . . „ 8.	47.7696	0.001200
19.	— - 2 „ I . . . . „ 8.	47.7702	0.001200
20.	— - 2 „ I . . . . „ 4.	47.7810	0.001200
21.	— - 2 „ I . . . . „ 4.	47.7808	0.001200
22.	— - 2 „ I . . . . „ 13.	47.7487	0.001198
23.	— - 2 „ I . . . . „ 13.	47.7484	0.001198
24.	— - 2 med rent Vand „ 0.	46.9773	0.001191
25.	— - 2 „ „ „ „ 0.	46.9776	0.001191
26.	— - 2 tomt	18.5658	0.001191
27.	— - 1 „	15.9216	0.001191
28.	— - 2 „	18.5656	0.001231
29.	— - 1 „	15.9213	0.001231

Til Bestemmelse af Udvidelsescoefficienten af det anvendte Glas forarbeidedes af det samme Glasrør et andet engrenet Pyknometer nedentil tilsmeltet og oventil forsynet med et Capillarrør, idet der ogsaa her sørgedes for Opvarmning af en saa liden Del af Røret som muligt. Ved

as possible of the wider tubes, lest it should give to the apparatus a coefficient of expansion different to that which the glass tubes originally had. The pycnometer was not made use of for the experiments to be described here, till about 4 months after the tubes of which it consisted had been sealed together; for the contraction peculiar to all articles of glass throughout the first few months after they have been blown might otherwise have occasioned an appreciable change in its volume during the progress of the observations. For the first experiments, the pycnometer was used without a receiver, but subsequently, when filled at a lower temperature, one had to be provided, adapted so as to admit of its being drawn over the capillary tube. The apparatus when used *without* a receiver I shall designate for the sake of brevity 'Pycnometer No. 1,' and when used *with* a receiver, 'Pycnometer No. 2.' By means of this instrument the following experiments were performed, in the order in which they are here arranged.

	Pycnometer with Contents.	Weight in Grammes.	In Air with a Sp. Gr. of
1.	Pycn. No. 1 empty	15.9222	0.001200
2.	— - 1 „	15.9223	0.001200
3.	— - 1 with pure water of 17.°5	44.3153	0.001200
4.	— - 1 „ „ „ „ 17.5	44.3156	0.001201
5.	— - 1 „ „ „ „ 17.5	44.3151	0.001201
6.	— - 1 „ III . . . . „ 17.5	44.8097	0.001201
7.	— - 1 „ III . . . . „ 17.5	44.8093	0.001201
8.	— - 1 „ VII . . . . „ 17.5	45.0742	0.001200
9.	— - 1 „ VII . . . . „ 17.5	45.0738	0.001200
10.	— - 2 empty	18.5665	0.001194
11.	— - 2 with I . . . . of 0.°	47.7869	0.001198
12.	— - 2 „ I . . . . „ 0.	47.7873	0.001198
13.	— - 2 „ I . . . . „ 0.	47.7871	0.001199
14.	— - 2 „ I . . . . „ 17.°5	47.7249	0.001201
15.	— - 2 „ I . . . . „ 17.5	47.7246	0.001201
16.	— - 2 „ I . . . . „ 20.	47.7085	0.001198
17.	— - 2 „ I . . . . „ 20.	47.7087	0.001198
18.	— - 2 „ I . . . . „ 8.	47.7696	0.001200
19.	— - 2 „ I . . . . „ 8.	47.7702	0.001200
20.	— - 2 „ I . . . . „ 4.	47.7810	0.001200
21.	— - 2 „ I . . . . „ 4.	47.7808	0.001200
22.	— - 2 „ I . . . . „ 13.	47.7487	0.001198
23.	— - 2 „ I . . . . „ 13.	47.7484	0.001198
24.	— - 2 with pure water „ 0.	46.9773	0.001191
25.	— - 2 „ „ „ „ 0.	46.9776	0.001191
26.	— - 2 empty	18.5658	0.001191
27.	— - 1 —	15.9216	0.001191
28.	— - 2 —	18.5656	0.001231
29.	— - 1 —	15.9213	0.001231

For determining the coefficient of expansion of the glass, a single-branched pycnometer was constructed, of the same length of glass tubing, with the lower opening sealed up and the upper extremity bearing a capillary tube, care being taken, as before, not to heat a greater part of the large tube than

Hjælp af dette Apparat, som ved et Stykke Kautschukrør var forbundet med et lidet Reservoir, bestemt til Optagelse af den ved mulig Opvarmning udskudte Del af Indholdet, bestemtes nu Udvidelsescoefficienten af det anvendte Glasrør med renset Kviksølv, som nogen Tid før Forsøgenes Udførelse under Udkogning paafyldtes Pyknometret. Med dette Apparat, som jeg vil betegne som Pyknometer No. 3, udførtes til den Ende følgende Veininger.

	Pyknometer med Indhold.	Vægt Gr.	I Luft af sp. Vægt.
30.	Pykn. No. 3 tomt	10.8654	0.001214
31.	— - 3 „	10.8653	0.001214
32.	— - 3 med Kviksølv af 0°	195.9265	0.001215
33.	— - 3 „ „ „ 0	195.9265	0.001215
34.	— - 3 „ „ „ 20	195.3588	0.001205
35.	— - 3 „ „ „ 20	195.3592	0.001205
36.	— - 3 „ „ „ 15	195.4993	0.001205
37.	— - 3 „ „ „ 0	195.9276	0.001205
38.	— - 3 tomt	10.8650	0.001203
39.	— - 3 med rent Vand af 4°	24.4621	0.001202
40.	— - 3 „ „ „ „ 4	24.4634	0.001190

Alle disse Veininger ere udførte efter Substitutionsmethoden ved Aflæsning af Svingninger paa en Vægt, hvis Følsomhed uden Belastning beløb sig til 1.4 Mgr. pr. Delstreg og for stigende Belastning temmelig jevnt aftog indtil 1.9 Mgr. ved 200 Gr. Belastning. Til disse saavel som alle finere Veininger, som jeg har foretaget i Anledning af disse Arbeider, benyttedes en Platinalodsats fra Deleuil i Paris, hvis Correctioner jeg i Forveien havde bestemt ved flere vel overensstemmende Veininger paa en af P. Bunge forarbeidet fortrinlig Vægt, hvis Følsomhed for de her omhandlede Belastninger beløb sig til omkring 0.14 Mgr. Ved Veiningerne iagttoges altid Temperatur og Barometerstand af Luften i Veieværelset, hvorimod dens Fugtighedsgrad i Mangel af Observation passende ansattes, en Mangel, der ikke har nogen mærkbar Indflydelse paa Forsøgenes Paalidelighed, da selv en saa grov Feil i Ansættelsen af Luftens relative Fugtighed som 25 % under de her omhandlede Forhold kun virker paa det endelige Resultat med en liden Feil i 6te Decimal. Efter disse Data er Luftens specifiske Vægt under Veiningerne paa vanlig Maade beregnet og opført i Tabellen. Pyknometret blev for hver særskilt opført Veining indstillet paany for Temperaturen 0° i finstødt Is og forøvrigt i Vandbad, hvis Temperatur under stadig Omrøring holdtes constant, ligesom det mindst en Gang for hver anden Veining tømtes og fyldtes igjen med det Søvand, hvis Volum skulde bestemmes. Ingen Indstilling toges for god, med mindre det lykkedes i mindst 15 Minutter at holde Temperaturen saa constant, at Thermometret ingensinde viste Variationer af 0.°1 eller derover. Til Brug ved Aflæsning af Vandbadets Temperatur tjente

absolutely unavoidable. With this apparatus, which was connected by a caoutschouc tube with a small receiver for collecting any portion of the contents that, in the event of the instrument becoming warmer might possibly be expelled, the coefficient of expansion of the glass tube was now determined by means of purified mercury, which, shortly before the commencement of the experiment, had, when boiling out the air, been introduced into the pycnometer. With this apparatus, which I will designate 'Pycnometer No. 3,' were performed the following determinations of weight: —

	Pycnometer with Contents.	Weight in Grammes.	In Air with a Sp. Gr. of
30.	Pycn. No. 3 empty	10.8654	0.001214
31.	— - 3 „	10.8653	0.001214
32.	— - 3 with mercury of 0°	195.9265	0.001215
33.	— - 3 „ „ „ 0	195.9265	0.001215
34.	— - 3 „ „ „ 20	195.3588	0.001205
35.	— - 3 „ „ „ 20	195.3592	0.001205
36.	— - 3 „ „ „ 15	195.4993	0.001205
37.	— - 3 „ „ „ 0	195.9276	0.001205
38.	— - 3 empty	10.8650	0.001203
39.	— - 3 with pure water „ 4°	24.4621	0.001202
40.	— - 3 „ „ „ „ 4	24.4634	0.001190

These weight-determinations were all performed according to the substitution method, by reading the oscillations of a balance, the sensibility of which, when not loaded, amounted to 1.4^{mgr} for every division of the scale, diminishing, on being loaded with successive weights, at a comparatively uniform rate down to 1.9^{mgr}, when loaded with 200^{gr}. For the above-mentioned as for all accurate weight-determinations involved in these labours, I made use of a set of platina weights procured from Deleuil in Paris, the corrections of which I had previous to starting on the Expedition computed from a series of closely agreeing determinations of weight performed with an excellent balance (made by P. Bunge), its sensibility when loaded to the extent here specified being nearly 0.14^{mgr}. When performing the weight-determinations, the temperature and the atmospheric pressure in the room were always observed, but the relative humidity not having been found by observation had to be roughly estimated, a source of inaccuracy which however can exert no appreciable influence on the trustworthiness of the experiments, seeing that an error of even 25 per cent in the computation of the relative humidity of the atmosphere would affect the final result only by occasioning a very small error in the 6th decimal. From these data, the specific gravity of the air during the process of weighing was computed in the usual manner, and entered in the Table. For each successive determination, the pycnometer was placed in finely crushed ice, to give it the temperature of 0°, and for every other required, in a water-bath, which by constant stirring was kept at an equable temperature; it was emptied,

et Thermometer, inddelt i Delstreger af Værdi 0.°2 med en Længde af 0.68^{mm}., hvis Correctioner bestemtes ved gjentagne Sammenligninger med det herværende meteorologiske Instituts Normalthermometer, som til det Brug velvillig blev mig laant af Institutets Bestyrer, Professor Dr. Mohn.

Af Observationerne 32 til 37 kan først Udvidelsen af det til Pyknometrene benyttede Glasrør beregnes, og man erholder, naar de af Wüllner[1] beregnede Værdier for Kviksølvets Udvidelse lægges til Grund, som Udtryk for Glassets midlere Udvidelsescoefficient mellem 0° og 15° 0.0000267 og mellem 0° og 20° 0.0000274. Man kan desuden ogsaa benytte Observationerne 3, 4 og 5 i Forbindelse med 24 og 25 til Beregning af Glassets Udvidelse og erholder, naar man anvender de af Hällström[2] og Rosetti[3] bestemte Værdier for Vandets Udvidelse, meget vel overensstemmende Tal, som i Middel fastsætte Glassets midlere Udvidelsescoefficient mellem 0° og 17.°5 til 0.0000275. Efterat man heraf har bestemt en passende Værdi for Glassets Udvidelse, hvorved naturligvis de med Kviksølv udførte Bestemmelser fortrinsvis maa komme i Betragtning, kan man nu skride til Udledelsen af de videre Resultater af Forsøgene. Man maa imidlertid her tage Hensyn til, at Observationerne 1, 2, 10, 26, 27, 28 og 29 tydeligt bevise, at Pyknometret under Forsøgene har tabt omkring 0.7 Mgr. i Vægt, hvad der rimeligvis skriver sig fra Opløsning af en Del af Glasset paa de ydre Vægge paa Grund af den stadige Omrøring i Badet. Den herved foraarsagede Usikkerhed kan dog betydelig reduceres, naar man beregner Pyknometrets Vægt til enhver Tid under Forudsætning af, at Vægttabet er proportionalt med Observationernes Antal, idet Usikkerheden da knapt nok vil influere paa 5te Decimal. Under denne Forudsætning har jeg senere beregnet følgende Resultater, idet jeg paa enkelte Steder har tilladt mig smaa Aproximationer, som imidlertid kun kan virke paa de endelige Værdier med en liden Feil i 6te Decimal.

Egenvægt ved	$\frac{17.^\circ5}{17.^\circ5}$	af III	1.01739.
	$\frac{17.^\circ5}{17.^\circ5}$	af VII	1.02669.
	$\frac{17.^\circ5}{17.^\circ5}$	af I	1.02691.
	$\frac{0^\circ}{0^\circ}$	af I	1.02845.

[1] Pogg. Ann. 153 — 440.

[2] Disse Værdier ere ogsaa af Ekman benyttede til Bestemmelse af Udvidelsen af det Dilatometer, som denne til sine Forsøg over Søvandets Udvidelse har anvendt.

[3] Ann. Chim. Phys. [4] — 17 — 372.

too, at least once for every other determination, and again filled with the sea-water the volume of which had to be found. These observations were in no case considered satisfactory unless the temperature of the water-bath had been kept comparatively uniform for at least 15 minutes, the greatest variation indicated by the thermometer during that interval never having exceeded 0.°1. For reading the temperature of the water-bath, a thermometer graduated in divisons of 0.°2, measuring each 0.68^{mm}, was made use of, the instrument having been previously corrected by frequent comparison with the standard thermometer of the Norwegian Meteorological-Institute, which the Director, Professor H. Mohn, had kindly lent me for that purpose.

Nos. 32—37 are the first of the observations by which the expansion of the glass in the pycnometer may be computed; and, taking the values found by Wüllner[1] for the expansion of mercury as the basis of calculation, the mean coefficient of expansion of the glass between 0° and 15° will be 0.0000267, and between 0° and 20°, 0.0000274. Moreover, Nos. 3, 4, and 5, in conjunction with Nos. 24 and 25, will also serve for determining the expansion of the glass; and, adopting the values computed by Hallström[2] and Rosetti[3] for the expansion of water, very closely agreeing results will be obtained, the figures expressing the average mean coefficient of expansion of the glass between 0° and 17.°5 being 0.0000275. After a proportionate value of the expansion of the glass has been found, for computing which preference should be given to the determinations performed with mercury, we may proceed to deduce the further results of the experiments. Meanwhile, regard must be had to the fact, of which the observations 1, 2, 10, 26, 27, 28, and 29 afford conclusive proof, that the pycnometer had lost about 0.7^{mgr} in weight during the progress of the experiments, some portion of the outer surface of the glass having probably been dissolved, a result of the constant motion of the water surrounding the instrument when in the water-bath. The uncertainty this occasions may however be very considerably reduced by computing the weight of the pycnometer for every experiment on the assumption that the loss of weight is proportional to the number of observations; in that case it will hardly influence the 5th decimal. On the basis of this assumption, I subsequently computed the following results, introducing here and there slight approximations, which, however, can affect the final result only by occasioning a small error in the 6th decimal.

Specific Gravity at	$\frac{17.^\circ5}{17.^\circ5}$	of III	1.01739.
	$\frac{17.^\circ5}{17.^\circ5}$	of VII	1.02669.
	$\frac{17.^\circ5}{17.^\circ5}$	of I	1.02691.
	$\frac{0^\circ}{0^\circ}$	of I	1.02845.

[1] Pogg. Ann. 153, p. 440.

[2] These values were also adopted by Ekman for determining the expansion of the dilatometer which he used when investigating the expansion of sea-water.

[3] Ann. Chim. Phys. [4], 17, p. 372.

og som Control paa det benyttede Kviksølvs Renhed dettes Egenvægt ved $\frac{0°}{4°}$ til 13.5963

samt Søvandets Volumina ved forskjellige Temperaturer til

$t°$	0	4	8	13	17.5	20
V_t af I	1.000000	1.000308	1.000794	1.001654	1.002605	1.003227

Til Udjevning af den efter disse Observationer optrukne Curve har jeg benyttet de mindste Kvadraters Methode, idet jeg har sat Ligningen for Søvandets Volum ved $t°$ under Formen

$$V_t = 1 + at + bt^2 + ct^3.$$

Betingelsesligningerne blive

$$\begin{aligned} a + 4\ b + 16\ c - 0.000077 &= 0 \\ a + 8\ b + 64\ c - 0.00009925 &= 0 \\ a + 13\ b + 169\ c - 0.00012723 &= 0 \\ a + 17.5b + 306.25c - 0.000148857 &= 0 \\ a + 20\ b + 400\ c - 0.00016135 &= 0 \end{aligned}$$

hvoraf Systemerne

$$\begin{aligned} 5a + 62.5\ b + 955.25c - 0.000613687 &= 0 \\ 62.5a + 955.25b + 16132.37c - 0.008588 &= 0 \\ 955.25a + 16132.37b + 286702\ c - 0.1392135 &= 0 \end{aligned}$$

som ved Elimination giver

$$\begin{aligned} a &= 0.0000527328 \\ b &= 0.00000617375 \\ c &= -0.000000037516 \end{aligned}$$

eller ved Afrunding

$$V_t = 1 + 0.0000527333t + 0.0000061738t^2 - 0.00000003752t^3.$$

Efter denne Formel har jeg beregnet følgende Tabel, hvori Søvandets Volum findes opført for hver hel Grad ogsaa for Temperaturerne under 0°, uagtet Formelens Gyldighed for dette Strøg ikke er støttet ved nogen Observation.

$t°$	V_t	$t°$	V_t	$t°$	V_t
—4	0.99989	5	1.00041	14	1.00185
—3	0.99990	6	1.00053	15	1.00205
—2	0.99992	7	1.00066	16	1.00227
—1	0.99995	8	1.00080	17	1.00250
0	1.00000	9	1.00095	17.5	1.00261
1	1.00006	10	1.00111	18	1.00273
2	1.00013	11	1.00128	19	1.00297
3	1.00021	12	1.00146	20	1.00322
4	1.00031	13	1.00165		

and, as a test of purity, the specific gravity of the mercury at $\frac{0°}{4°}$ was found to be 13.5963, and

the volume of sea-water at different temperatures —

$t°$	0	4	8	13	17.5	20
V_t of I	1.000000	1.000308	1.000794	1.001654	1.002605	1.003227

For smoothing the curve laid down from these observations, I adopted the method of the least squares, giving the equation for the volume of the sea-water at $t°$ the form —

$$V_t = 1 + at + bt^2 + ct^3.$$

The conditional equations will be —

$$\begin{aligned} a + 4\ b + 16\ c - 0.000077 &= 0 \\ a + 8\ b + 64\ c - 0.00009925 &= 0 \\ a + 13\ b + 169\ c - 0.00012723 &= 0 \\ a + 17.5b + 306.25c - 0.000148857 &= 0 \\ a + 20\ b + 400\ c - 0.00016135 &= 0 \end{aligned}$$

from which are deduced —

$$\begin{aligned} 5a + 62.5\ b + 955.25c - 0.000613687 &= 0 \\ 62.5a + 955.25b + 16132.37c - 0.008588 &= 0 \\ 955.25a + 16132.37b + 286702\ c - 0.1392135 &= 0 \end{aligned}$$

and these equations give by elimination —

$$\begin{aligned} a &= 0.0000527328 \\ b &= 0.00000617375 \\ c &= -0.000000037516 \end{aligned}$$

or, rounded off,

$$V_t = 1 + 0.0000527333t + 0.0000061738t^2 - 0.00000003752t^3.$$

By means of this formula I determined the results set forth in the following Table, which shows the volume of sea-water, computed for every degree, including temperatures below 0°, although the applicability of the formula to the latter has not been ascertained from observation.

$t°$	V_t	$t°$	V_t	$t°$	V_t
—4	0.99989	5	1.00041	14	1.00185
—3	0.99990	6	1.00053	15	1.00205
—2	0.99992	7	1.00066	16	1.00227
—1	0.99995	8	1.00080	17	1.00250
0	1.00000	9	1.00095	17.5	1.00261
1	1.00006	10	1.00111	18	1.00273
2	1.00013	11	1.00128	19	1.00297
3	1.00021	12	1.00146	20	1.00322
4	1.00031	13	1.00165		

Til Sammenligning hidsættes her de af Ekman fundne Værdier for Volumet af 4 Vandprøver *A, B, C* og *D* af respective Egenvægter ved $\frac{15^\circ}{15^\circ}$ 1.01603, 1.01982, 1.02306, og 1.02695.

t°	V_t af *A*	V_t af *B*	V_t af *C*	V_t af *D*
—5	1.000145	1.000061	0.999983	0.999902
—4	1.000087	1.000020	0.999959	0.999894
—3	1.000044	0.999994	0.999948	0.999904
—2	1.000015	0.999983	0.999953	0.999922
—1	1.000001	0.999985	0.999969	0.999955
0	1.000000	1.000000	1.000000	1.000000
1	1.000019	1.000035	1.000043	1.000062
2	1.000047	1.000083	1.000100	1.000136
3	1.000096	1.000142	1.000168	1.000220
4	1.000154	1.000213	1.000249	1.000315
5	1.000223	1.000296	1.000344	1.000421
6	1.000305	1.000390	1.000450	1.000537
7	1.000399	1.000495	1.000567	1.000664
8	1.000504	1.000612	1.000696	1.000801
9	1.000621	1.000739	1.000836	1.000948
10	1.000749	1.000877	1.000985	1.001104
11	1.000888	1.001026	1.001145	1.001272
12	1.001038	1.001185	1.001315	1.001449
13	1.001199	1.001354	1.001495	1.001635
14	1.001370	1.001533	1.001683	1.001831
15	1.001551	1.001719	1.001880	1.002038
16	1.001742	1.001925	1.002085	1.002250
17	1.001943	1.002134	1.002299	1.002473
18	1.002153	1.002353	1.002520	1.002705
19	1.002373	1.002582	1.002749	1.002946
20	1.002601	1.002819	1.002984	1.003195
21	1.002839	1.003062	1.003227	1.003453
22	1.003085	1.003321	1.003474	1.003719
23	1.003340	1.003588	1.003728	1.003993
24	1.003602	1.003861	1.003988	1.004275
25	1.003875	1.004144	1.004253	1.004565

For den af mig undersøgte Vandprøve I er efter de forhen beskrevne Observationer fundet Egenvægten 1.02691 ved $\frac{17.^\circ5}{17.^\circ5}$ eller 1.02707 reduceret til $\frac{15^\circ}{15^\circ}$, medens Ekman for Vandprøven *D* har fundet Egenvægten 1.02695 ved $\frac{15^\circ}{15^\circ}$, og det fremgaar saaledes, at Undersøgelserne for disse Vandprøvers Vedkommende meget godt kunne gjøres til Gjenstand for Sammenligning. En saadan Sammenligning viser let, at der paa alle Puncter selv for Temperaturerne under 0° existerer en tilfredsstillende Overensstemmelse, idet Differentserne i Regelen ikke overstige 0.00001 og for de høiere Temperaturer, hvor de antage sin største Værdi, kun gaa op til omtrent 0.000025, en Uoverensstemmelse, som, naar Hensyn tages til Forskjellen mellem Vandprøvernes Egenvægter, end yderligere kan reduceres. Med de ovenfor nævnte af andre Chemikere udførte Undersøgelser

For comparison with these figures, are annexed the values found by Ekman for the volume of 4 samples of sea-water, *A, B, C,* and *D,* their specific gravity at $\frac{15^\circ}{15^\circ}$ being respectively 1.01603, 1.01982, 1.02306, and 1.02695.

t°	V_t of *A.*	V_t of *B*	V_t of *C*	V_t of *D*
—5	1.000145	1.000061	0.999983	0.999902
—4	1.000087	1.000020	0.999959	0.999894
—3	1.000044	0.999994	0.999948	0.999904
—2	1.000015	0.999983	0.999953	0.999922
—1	1.000001	0.999985	0.999969	0.999955
0	1.000000	1.000000	1.000000	1.000000
1	1.000019	1.000035	1.000043	1.000062
2	1.000047	1.000083	1.000100	1.000136
3	1.000096	1.000142	1.000168	1.000220
4	1.000154	1.000213	1.000249	1.000315
5	1.000223	1.000296	1.000344	1.000421
6	1.000305	1.000390	1.000450	1.000537
7	1.000399	1.000495	1.000567	1.000664
8	1.000504	1.000612	1.000696	1.000801
9	1.000621	1.000739	1.000836	1.000948
10	1.000749	1.000877	1.000985	1.001104
11	1.000888	1.001026	1.001145	1.001272
12	1.001038	1.001185	1.001315	1.001449
13	1.001199	1.001354	1.001495	1.001635
14	1.001370	1.001533	1.001683	1.001831
15	1.001551	1.001719	1.001880	1.002038
16	1.001742	1.001925	1.002085	1.002250
17	1.001943	1.002134	1.002299	1.002473
18	1.002153	1.002353	1.002520	1.002705
19	1.002373	1.002582	1.002749	1.002946
20	1.002601	1.002819	1.002984	1.003195
21	1.002839	1.003062	1.003227	1.003453
22	1.003085	1.003321	1.003474	1.003719
23	1.003340	1.003588	1.003728	1.003993
24	1.003602	1.003861	1.003988	1.004275
25	1.003875	1.004144	1.004253	1.004565

According to the observations previously described the specific gravity of sample I, was, at $\frac{17.^\circ5}{17.^\circ5}$, 1.02691, or, reduced to $\frac{15^\circ}{15^\circ}$, 1.02707, and Ekman found the specific gravity of sample *D* to be 1.02695 at $\frac{15^\circ}{15^\circ}$. Hence the results, so far at least as these samples are concerned, very well admit of being compared; satisfactory agreement exists even for temperatures below 0°, since the difference does not as a rule exceed 0.00001, and for the highest temperatures, at which it is greatest, it amounts to only 0.000025; nay, these figures may be still further reduced by taking into account the specific gravities of the samples. With the results of the above-mentioned observations instituted by other chemists, those here described agree but indifferently. According to the formula deduced by

stemme de her beskrevne Resultater kun maadeligt overens. Ifølge den af Wackerbarth efter Ekmans Observationer beregnede Formel er Temperaturen for Tæthedsmaximum hos Søvand af Egenvægt 1.02707 = — 4.°04, medens Ligningen $\frac{dV}{dt} = 0$ med de af mig fundne Coefficienter giver Temperaturen —4.°45.

Paa Grund af denne gjennemførte Overensstemmelse mellem Ekmans og mine Resultater, har jeg ikke fundet det fornødent at bestemme Udvidelsen af Vandprøver af lavere Egenvægt, men har uden videre anvendt Ekmans Observationer paa de faa Puncter, hvor jeg til Reduction af de paa den norske Nordhavsexpedition aflæste Egenvægter har havt Brug for dem. Ved Hjælp af de ovenfor opførte Værdier for Søvandets Volumina ved forskjellige Temperaturer kan man nu beregne de Correctioner, hvormed de ved vilkaarlige Temperaturer aflæste Egenvægter maa forbedres forat reduceres til $\frac{17.°5}{17.°5}$. Correctionerne, hvori ogsaa indgaar et Led, der afhænger af Aræometrenes Udvidelsescoefficient,[1] findes sammenstillede i nedenstaaende Tabel.

$t°$	Correction	$t°$	Correction
0	—0.00224	12	—0.00104
2	—0.00214	14	—0.00069
4	—0.00201	16	—0.00031
6	—0.00183	18	0.00011
8	—0.00161	20	0.00056
10	—0.00134		

Hvor den Temperatur, hvorved Aflæsningen foretages, ikke fjerner sig meget fra Normaltemperaturen 17.°5, kan disse Correctioner, der strengt taget kun gjælde for Søvand af Egenvægt omkring 1.027, ogsaa uden mærkelig Feil anvendes for Vandprøver af en derfra temmelig forskjellig Egenvægt. Hvor derimod den Temperatur, hvorved Aflæsningen foretages, ligger langt fra 17.°5, ere disse Correctioner kun gyldige for et meget begrændset Interval.

Efterat saaledes de aflæste Egenvægter ved Anbringelse af disse Correctioner ere reducerede til Normaltemperaturen, staar det endnu tilbage at befrie dem for de ved de benyttede Aræometre heftende constante Feil.

Til Aflæsning af saa godt som alle paa Expeditionen bestemte Egenvægter benyttedes kun 3 Aræometre, to paa første Togt og et paa de to sidste. Af de to først nævnte, der af Svendsen før Udreisen vare udvalgte af de øvrige, fordi de havde vist sig at stemme særdeles vel overens, er desværre det ene senere bleven knust, det andet er endnu i Behold og er sammen med det paa sidste Togt benyttede bleven corrigeret af mig.

[1] Som saadan benyttedes 0.000026.

A. Wackerbarth from Ekman's observations, the temperature for the maximum density of sea-water with a specific gravity of 1.02707 is —4.°04, whereas the equation $\frac{dV}{dt} = 0$ gives, with my coefficients, a temperature of —4.°45.

Relying, then, on the close agreement between Ekman's results and my own, I have not determined the expansion in samples of sea-water with a lower specific gravity, but have adopted Ekman's observations, for reducing, when needful, the specific gravities read on the Norwegian North-Atlantic Expedition. By means of the values, tabulated above, for the volume of sea-water at different temperatures, the corrections which serve to reduce specific gravities read at any given temperature to $\frac{17.°5}{17.°5}$ may be computed. These corrections, into which the coefficient of expansion of the areometer[1] enters as a factor, are given in the following Table.

$t°$	Corrections	$t°$	Corrections
0	—0.00224	12	—0.00104
2	—0.00214	14	—0.00069
4	—0.00201	16	—0.00031
6	—0.00183	18	0.00011
8	—0.00161	20	0.00056
10	—0.00134		

When the temperature is not far removed from the normal temperature, 17.°5, these corrections, which, strictly speaking, apply only to sea-water with a specific gravity of about 1.027, may, without involving any appreciable error in the result, be likewise adopted for samples of water whose specific gravity differs considerably from that expressed by the above formula; but when, on the other hand, the temperature at which the specific gravity is read and that of 17.°5 lie far apart, the interval for which these corrections will serve is but very limited.

After reducing by means of these corrections the specific gravities to the normal temperature, there still remains to eliminate the constant error of the areometer.

For reading almost all of the specific gravities determined on the Expedition, only 3 areometers were made use of, two on the first cruise and one on the two last. Of the two former, which, having been found to agree uncommonly well, Mr. Svendsen had selected previous to his departure, one was unfortunately afterwards broken; the other is still in perfect order, and was, together with that made use of on the last voyage, corrected by myself.

[1] That adopted was 0.000026.

Correctionernes Bestemmelse udførtes ved Hjælp af Vandprøverne I og VII, hvis Egenvægter tidligere ere bestemte til 1.02691 og 1.02669 ved $\frac{17.°5}{17.°5}$. For det paa første Togt anvendte Aræometer erholdtes saaledes gjennem 5 Aflæsninger i I Correctionen —0.00023 og gjennem 12 Aflæsninger i VII ligeledes —0.00023. Paa samme Maade bestemtes det andet Aræometers Correctioner ved 5 Aflæsninger i I til —0.00037 og ved 8 Aflæsninger i VII til —0.00038. Under disse Aflæsninger var Vædsken altid bragt til 17.°5 eller en meget nærliggende Temperatur, hvorfra Aflæsningerne efter de forhen gjengivne Correctioner reduceredes til Normaltemperaturen. Gjennem flere Rækker Aflæsninger i Vandprøven I ved forskjellige Temperaturer har jeg tillige forvisset mig om, at den ved Beregning af Correctionstabellen benyttede Udvidelsescoefficient for Aræometrene er passende valgt.

Hermed er givet de fornødne Data til Reduction af de paa den norske Nordhavsexpedition aflæste Egenvægter, og jeg gaar dernæst over til Bestemmelsen af Relationerne mellem Saltgehalten, Chlormængden og Egenvægten.

Til Bestemmelse af Saltmængden har, saavidt jeg ved, tidligere kun været benyttet den simpleste Methode, bestaaende i Afdampning af Vandet og Residuets Tørring ved en passende Temperatur, som af de forskjellige Chemikere er bleven valgt noget forskjelligt fra 150°—180°. Denne Methode har jeg imidlertid af flere Grunde fundet lidet tilfredsstillende, hvad man ogsaa paa Forhaand maatte vente. Efter Graham[1] og andre taber nemlig den svovlsure Magnesia, om hvis Tilstedeværelse i Søvandet der vel ikke kan reises Tvivl, først ved en Temperatur af over 200° sit sidste Molekyl Vand, medens man paa den anden Side allerede ved en Temperatur af betydeligt under 200° maa befrygte en delvis Decomposition af den i Saltene tilstedeværende Chlormagnesium. Efter de Forsøg, som jeg anstillede, viste det sig, at Saltene selv efterat være tørrede ca. 20 Timer i Luftbad ved en Temperatur fra 170°—180° endnu indeholdt ikke ubetydelige Mængder Vand (omkring 15 Mgr. pr. Gr. Salt), medens de tørrede ved lidt lavere Temperatur indeholdt noget mere. Samtidig undersøgtes ogsaa Saltene paa fri Magnesia, hvorved jeg i Strid med ældre Angivelser fandt, at de bestandig selv ved Tørring ved 160° til 170° indeholdt uventet store Qvantiteter, saaat der for hvert Gr. tørret Salt fandtes en Magnesiamængde tilstrækkelig til at neutralisere over 20 Mgr. HCl (ved Tørring ved 180° fandt jeg endog en enkelt Gang 40 Mgr.). Bestemmelsen af den frie Magnesia foretoges ved Saltenes Opløsning i en afmaalt Mængde titreret Svovlsyre og derpaa følgende Retitration med fortyndet Natronlud af bekjendt Styrke. Ved Anvendelse af Rosolsyre som Index erholdtes her en meget skarp Endereaction.

[1] Phil. Mag. J. 6 — 422.

The determination of the corrections was performed with the water of samples I and VII, whose specific gravity at $\frac{17.°5}{17.°5}$ had been found to be respectively 1.02691 and 1.02669. For the areometer used on the first voyage, 5 readings with the water of sample I gave the correction —0.00023, and 12 readings with the water of sample VII likewise —0.00023; in the same manner, the corrections for the other areometer were determined, by 5 readings with the water of sample I, to be —0.00037, and, by 8 readings with the water of sample VII, to be —0.00038. For these readings, the fluid was always brought to 17.°5, or as near that temperature as possible, the readings having in the latter case to be reduced, by means of the corrections given above, to the normal temperature. Several series of readings with the water of sample I, at different temperatures, convinced me that the coefficient of expansion for the areometer which I had computed for preparing the Table of Corrections was practically correct.

Having now specified the data necessary for reducing the specific gravities read on the Norwegian North-Atlantic Expedition, I shall proceed to determine the relation between the specific gravity of sea-water and the amount of salt and chlorine it contains.

For determining the amount of salt, the only method formerly resorted to was, so far as I am aware, the simplest, viz. that of evaporating the water and then drying the residue at a proper temperature, which has been variously fixed by different chemists at from 150° to 180°. This method, however, has proved in several respects defective, as was indeed to be expected. According to Graham[1] and others, sulphate of magnesia, the presence of which in sea-water can hardly admit of doubt, does not part with its last molecule of water till exposed to a temperature of more than 200° whereas, on the other hand, it is highly probable that partial decomposition of the chloride of magnesium contained in the salt takes place considerably below 200°. Even after the salts had been dried for about 20 hours in an air-bath at a temperature of 170°—180°, they were still found to contain, according to my experiments, a considerable quantity of water (about 15^{mgr} salt per gramme); dried at a lower temperature, the amount was somewhat greater. I also tested the salts for free magnesia, and found, in direct opposition to earlier statements, that, even when dried at 160°—170°, they invariably contained a very large amount, the quantity of magnesia to every gramme of dried salt being sufficient to neutralize more than 20^{mgr} HCl (once, when dried at 180°, even 40^{mgr}). For determining the free magnesia, the salts were dissolved in a given quantity of titrated sulphuric acid, and the fluid then retitrated with dilute soda-lye of known strength. With rosolic acid as the index, the final reaction was very decided.

[1] Phil. Mag. J. 6, p. 422.

Forat undgaa de her omtalte Feil, benyttedes til Bestemmelse af Saltmængden i Søvandet følgende Fremgangsmaade.

I en med tætsluttende Laag forsynet tyk, veiet Porcellaindigel indveiedes 30 til 40 Gr. Søvand, som afdunstedes paa Vandbad. Efterat Saltene vare nogenlunde vel tørrede, opheddedes Digelen med Laaget paa ca. 5 Minutter over en Bunsens Lampe, afkjøledes og veiedes paany. Derefter bestemtes paa den forud beskrevne Maade den ved Decomposition af Chlormagnesium dannede frie Magnesia, hvorved de til Beregning af den samlede Saltgehalt fornødne Data erholdtes.

I en tidligere Afhandling[1] har jeg paavist, at Carbonaterne i Søvandet ved Kogning omsætter sig til kulsur Magnesia, som ved Inddampning eller under enhver Omstændighed ved Glødning efterlader Magnesia, og man skulde altsaa strengt taget for den saaledes dannede Del af den frie Magnesia beregne en anden Correction end for den ved Decomposition af Chlormagnesium dannede Hovedmængde. Den Feil, man begaar, ved at undlade dette er imidlertid baade meget nær constant og desuden saa liden, at den uden videre kan negligeres, idet den kun bidrager til at formindske den samlede Saltgehalt med omkring 0.0015 %. Det er saaledes fuldstændig tilstrækkeligt til den ved Veiningen fundne Mængde tørret Salt at addere 1.375 Gange den ved Titreringen bestemte Mængde fri Magnesia, for af det saaledes fremkomne Tal at beregne Saltgehalten i Procenter.

Mod denne Methode kan der dog reises Indvendinger, idet det kunde befrygtes, at mindre Qvantiteter Chlornatrium, Chlormagnesium eller Chlorkalium under Glødningen kunde forflygtiges, eller at en Del af den svovlsure Magnesia ved den høie Temperatur kunde decomponeres og give Anledning til Tab af Svovlsyre. Man kan imidlertid let forvisse sig om, at dette ved Anvendelse af en tyk Porcellaindigel med tætsluttende Laag ikke bevirker nogen Feil af mærkbar Indflydelse. Saaledes fandt jeg, at 1.2 Gr. af en passende Blanding af Chlorkalium og Chlornatrium ved $1^1/_4$ Times stærkest mulig Glødning over en Bunsens Lampe i den samme Digel, som jeg benyttede til mine Saltbestemmelser, kun tabte 2 Mgr. i Vægt, det vil sige, Blandingen tabte ved Glødningen ikke fuldt 0.14 Mgr. pr. 5 Minutter. Ligeledes paavistes ved Bestemmelse af Svovlsyre og Magnesia saavel i det benyttede Søvand som i det glødede Residuum, at man selv ved en meget længere fortsat Glødning end den, der udfordres forat skaffe fuldstændig vandfrit Salt, ikke risikerer nogen skadelig Feil foranlediget ved Forflygtigelse af Chlormagnesium eller Decomposition af svovlsur Magnesia.

[1] "Om Kulsyren i Søvandet" Side 40 øverst.

In order to guard against the above-mentioned errors, the following mode of operation was adopted for determining the amount of salt in sea-water.

From 30^{gr} to 40^{gr} of sea-water were introduced into a thick porcelain crucible of known weight, furnished with a tight-fittting cover, and evaporated on a water-bath. So soon as the salt was sufficiently dry, the crucible, with the cover on, was heated for about 5 minutes over one of Bunsen's gas-burners, then cooled and weighed with its contents. The free magnesia liberated by the decomposition of the chloride of magnesium was now determined in the manner previously described, and the last factor necessary for computing the total amount of salt accordingly found.

In a former paper[1] I drew attention to the fact, that the carbonates present in sea-water are transformed during the process of boiling into carbonate of magnesia, which after evaporation, or, at least, on the salt being thoroughly heated, leaves a residue of magnesia; and hence the proportion of free magnesia thus formed would, strictly speaking, seem to involve the need of a correction different from that adopted for the principal amount liberated by the decomposition of the chloride of magnesium. But the error which arises from applying the same correction to both is, on the one hand, very nearly constant, and, on the other, so small as to admit of being safely ignored, seeing that it reduces the total amount of salt only about 0.0015 per cent. It is, therefore, amply sufficient, if to the amount of dried salt found by weighing be added 1.375 times the amount of the free magnesia determined by titration: the figure thus obtained will serve to compute the percentage of salt.

This method certainly is so far open to objection, that small quantities of chloride of sodium, chloride of magnesium, or chloride of potassium may be volatilized during the process of heating, or some portion of the sulphate of magnesia be decomposed at the high temperature, and thus occasion a loss of sulphuric acid. The error, however, arising from this source will not exert any appreciable influence on the result, provided the crucible used for the operation be of thick porcelain, and have a tight-fitting cover. Thus, for instance, I found that 1.2^{gr} of a proportionate mixture of chloride of potassium and chloride of sodium, on being heated for the space of an hour and a quarter over one of Bunsen's gas-burners in the crucible I had used for my salt-determinations, lost only 2^{mgr} in weight, or 0.14^{mgr} every 5 minutes. Moreover, it was manifest on determining the sulphuric acid and magnesia both in the water itself and in the heated residue, that, even in the event of the heating-process being much more protracted than is necessary to obtain salt free from the smallest trace of water, no serious error can result from the volatilization of chloride of magnesium or the decomposition of sulphate of magnesia.

[1] "On the Carbonic Acid in Sea-Water," p. 40.

At Methoden giver indbyrdes vel overensstemmende Resultater, viser de talrige Saltbestemmelser, som udføres med samme Vandprøver. Saaledes fandtes ved nedenstaaende Forsøg

Proc. Salt i II {3.525, 3.517} — Proc. Salt i VII {3.514, 3.516, 3.515}

— — - III {2.303, 2.299}

— — - IV {3.386, 3.385}

— — - V {3.530, 3.533}

— — - VI {3.276, 3.279}

— — - VIII {3.501, 3.507, 3.508, 3.500, 3.502, 3.506, 3.500, 3.501}

Resultaterne ere, som man ser, allerede her temmelig vel overensstemmende, men kunde visselig gives en endnu større Nøiagtighed, om man vilde arbeide med noget større Quantiteter Søvand.

For Vandprøverne III og VII er Egenvægten ved $\frac{17.^{\circ}5}{17.^{\circ}5}$ allerede tidligere ved Hjælp af Pyknometer bestemt til respective 1.01739 og 1.02669, for Vandprøverne IV, V, VI og VIII er den funden ved gjentagne Aflæsninger paa et af de corrigerede Aræometre, medens den for Prøven II kun blev bestemt ved en enkelt Aflæsning. Ligeledes bestemtes meget omhyggeligt samtlige Vandprøvers Chlormængder. Heraf kan

$$\text{Chlorcoefficienten} = \frac{\text{Saltmængden}}{\text{Chlormængden}}$$

og

$$\text{Egenvægtscoefficienten} = \frac{\text{Saltmængden}}{\text{Egenvægten} - 1}$$

beregnes, saaledes som det er gjort i nedenstaaende Tabel.

No.	Egenvægt ved $\frac{17.^{\circ}5}{17.^{\circ}5}$	Chlor-mængde %	Salt-mængde %	Egen-vægts-coefficient.	Chlor-coefficient.
II	1.02670	1.947	3.521	131.9	1.808
III	1.01739	1.271	2.301	132.3	1.810
IV	1.02573	1.868	3.386	131.6	1.813
V	1.02676	1.956	3.532	132.0	1.806
VI	1.02488	1.809	3.278	131.8	1.812
VII	1.02669	1.947	3.515	131.7	1.805
VIII	1.02655	1.938	3.503	131.9	1.808

Som det heraf fremgaar, er baade Chlor- og Egenvægtscoefficienterne tiltrods for Saltgehalternes Forskjellighed overalt meget nær constante, saa at Variationerne

That the results obtained by this method must be regarded as agreeing very closely *inter se*, is shown by the numerous salt-determinations performed with the same samples of water.

Per cent. of Salt in II {3.525, 3.517} — Per cent. of Salt in VII {3.514, 3.516, 3.515}

" " - — - III {2.303, 2.299}

" " - — - IV {3.386, 3.385}

" " - — - V {3.530, 3.533}

" " - — - VI {3.276, 3.279}

" " - — - VIII {3.501, 3.507, 3.508, 3.500, 3.502, 3.506, 3.500, 3.501}

These figures, it will be seen, differ but little *inter se*, and by increasing the quantity of water greater accuracy could no doubt be attained.

For samples III and VII, the specific gravity at $\frac{17.^{\circ}5}{17.^{\circ}5}$, respectively 1.01739 and 1.02669, had been previously determined by means of the pycnometer; for samples IV, V, VI, and VIII, it was found by repeated readings of one of the corrected areometers, whereas for sample II it was determined by one reading only. The amount of chlorine, too, in each sample was carefully determined. From these data may be computed the

$$\text{Coefficient of Chlorine} = \frac{\text{Amount of Salt}}{\text{Amount of Chlorine}}$$

and the

$$\text{Coefficient of Specific Gravity} = \frac{\text{Amount of Salt}}{\text{Specific Gravity} - 1}$$

as set forth in the following Table.

No.	Spec. Grav. at $\frac{17.^{\circ}5}{17.^{\circ}5}$	Percentage of Chlorine.	Percentage of Salt.	Coefficient of Spec. Grav.	Coefficient of Chlorine.
II	1.02670	1.947	3.521	131.9	1.808
III	1.01739	1.271	2.301	132.3	1.810
IV	1.02573	1.868	3.386	131.6	1.813
V	1.02676	1.956	3.532	132.0	1.806
VI	1.02488	1.809	3.278	131.8	1.812
VII	1.02669	1.947	3.515	131.7	1.805
VIII	1.02655	1.938	3.503	131.9	1.808

It thus appears, that the coefficients both of chlorine and specific gravity, notwithstanding the difference in the percentage of salt, are always very nearly constant;

rimeligst bliver at tilskrive Observationsfeil. Som Chlorcoefficient kan heraf opstilles

1.809 ± 0.00076

med en sandsynlig Feil af en enkelt Bestemmelse af ± 0.002 og som Egenvægtscoefficient

131.9 ± 0.058

med en sandsynlig Feil af en enkelt Bestemmelse af ± 0.15.

Disse Værdier stemme især for Chlorcoefficientens Vedkommende ganske vel overens med tidligere fundne Værdier, saaledes har baade Forchhammer og Ekman i Middel fundet 1.811, medens de af Andre opstillede Egenvægtscoefficienter overalt ere noget mindre end den af mig fundne.

Ved Hjælp af disse Coefficienter har jeg af de paa Expeditionens Togter udførte Chlor- og Egenvægtsbestemmelser beregnet Vandprøvernes Saltgehalt og sammen med Originalobservationerne opført dem i nedenstaaende Tabel.

Egenvægterne ere i Regelen kun aflæste med 4 Decimaler, det 5te er kun opført, hvor det havde en Værdi nær 5, saa at det kunde være Tvivl underkastet, om der ved Afrunding skulde formindskes eller forhøies. I de reducerede Egenvægter findes ligeledes kun opført 4 Decimaler, hvor det uden Tvivl kunde afgjøres, til hvilken Side Afrundingen skulde finde Sted, hvorimod der i modsat Fald ogsaa der er tilføiet et 5te. De med * betegnede Egenvægter ere aflæste paa Aræometre, hvis Correction ikke er bleven bestemt. Til Optagelse af de til Undersøgelse af Saltholdigheden bestemte Vandprøver er foruden det tidligere beskrevne, af Wille construerede, Apparat ogsaa paa grundere Vand ofte benyttet den af Ekman angivne fortrinlige Vandhenter, som imidlertid ifølge den Fremgangsmaade, hvorefter Dyblodninger paa den norske Expedition foretoges, ikke egnede sig til Brug ved større Dyb.

Ved Velvillie af Professor Mohn har jeg faaet opgivet de undersøgte Vandprøvers Temperatur i Havet, hvorved det er bleven muligt ogsaa at tilføie en Rubrik for deres Egenvægter ved denne Temperatur i Forhold til rent Vand af 4°.[1] Af de i Tabellen gjengivne Observationer ere alle indtil No. 149 udførte paa 1ste Togt af Svendsen, alle fra 149 til 225 paa 2det Togt af mig, de øvrige ere udførte paa sidste Togt af Schmelck og mig i Fællesskab, saaledes at det største Antal skyldes Schmelck, der dette Aar medfulgte Expeditionen.

[1] Rent Vand af 4° er ved denne Reduction valgt som Enhed, fordi den allerede tidligere er anvendt af J. Y. Buchanan (Proc. Roy. Soc. 24—597). Ved Beregning af Egenvægternes Værdi ved Havets Temperatur i Forhold til Vand af 4° er Forholdet mellem Volumet af rent Vand ved 4° og 17.°5 sat = 0.998768.

and hence the variation in the results should most probably be ascribed to errors of observation. The coefficient of chlorine may accordingly be taken at —

1.809 ± 0.00076

with a probable error in a single determination of ± 0.002, and the coefficient of specific gravity, at —

131.9 ± 0.058

with a probable error in a single determination of ± 0.15.

These values agree closely, in particular as regards the coefficient of chlorine, with those previously found. Thus, for instance, the mean value found both by Forchhammer and Ekman was 1.811, whereas the coefficient of specific gravity given by former observers is somewhat lower than mine.

By means of these coefficients I have computed from the determinations of chlorine and specific gravity the amount of salt in the samples of water collected on the Expedition, and have set down the observations and their results in the accompanying Table, which calls for a brief explanation.

The specific gravities are as a rule not read to more than 4 decimals, a fifth being added only in the event of its having a value of 5, in which case it is often doubtful whether, when rounding off the figures, there should be increase or diminishment. The reduced specific gravities, too, are expresed with 4 decimals only, wherever it was manifest in which direction the rounding off had to be made; when such is not the case, a fifth has been added. An asterisk at the side of a specific gravity denotes that the latter was determined with an areometer for which no correction had been found. Besides the instrument devised by Wille, of which a description has been given, Ekman's excellent apparatus was likewise made use of, in comparatively shallow localities, for collecting the samples of sea-water in which to determine the amount of salt; the mode of sounding practised on the Norwegian North-Atlantic Expedition would not admit of its adoption for greater depths.

Professor Mohn has kindly furnished me with the temperatures of the samples of water *in situ*, which has enabled me to give an aditional column for the specific gravities at those temperatures as compared with pure water of 4°.[1] Of the observations given in the Table, those extending from No. 1 to No. 149 were performed on the first voyage, by Mr. Svendsen; those extending from No. 149 to No. 225, on the second voyage, by myself; the remainder were taken on the last voyage, by Mr. Schmelck and myself conjointly, the greater number, however, by Mr. Schmelck, who that year accompanied the Expedition.

[1] Pure water of 4° was chosen as the unit of reduction, J. Y. Buchanan having previously adopted it as such (Proc. of Roy. Soc. 24, p. 597). When computing the specific gravities at the temperature of the sea, as compared with water of 4°, the ratio existing between the volume of pure water at 4° and 17.°5 was assumed to be 0.998768.

Tab. III.

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.) Engelske Favne. (English Fathoms.)	Meter. (Metres.)	Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.) Under Aflæsningen. (When read.)	I Havet. (In Situ.) t^0	Egenvægter. (Specific Gravity.) Ved $\frac{17.^05}{17.^05}$ (At $\frac{17.^05}{17.^05}$)	Ved $\frac{t^0}{4^0}$ (At $\frac{t^0}{4^0}$)	Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.) Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
1	—	Esefjord, Sogn.		0	0	1.0151*	14.8	—	1.01465	—	—	1.93	—
2	—	Do.		1	2	1.0234*	13.7	—	1.0227	—	—	2.99	—
3	—	Do.		2	4	1.0237*	12.5	—	1.0228	—	—	3.01	—
4	—	Do.		3	5	1.0241*	13.0	—	1.0233	—	—	3.07	—
5	—	Do.		4	7	1.0242*	13 8	—	1.0235	—	—	3.10	—
6	—	Do.		5	9	1.0240*	17.3	—	1.02395	—	—	3.16	—
7	—	Do.		6	11	1.0245*	17.0	—	1.0244	—	—	3.22	—
8	—	Do.		7	13	1.0249*	20.0	—	1.02545	—	—	3.36	—
9	2	61° 9.'6	6° 31.'9	672	1229	1.0270	16.7	6.7	1.0266	1.0274	—	3.51	—
10	—	Fjærland.		0	0	1.0118*	9.2	—	1.0107	—	—	1.41	—
11	—	Esefjord.		0	0	1.0147*	12.0	—	1.0139	—	—	1.46	—
12	—	Do.		1	2	1.0188*	12.5	—	1.0180	—	—	2.37	—
13	3	61° 5.'2	5° 15.'3 E.	618	1130	1.0280	11.0	6.6	1.0266	1.0274	—	3.51	—
14	—	Husø.		0	0	1.0262	9.7	—	1.0246	—	—	3.24	—
15	—	Do.		0	0	1.0262	9.9	—	1.02465	—	—	3.25	—
16	—	Do.		0	0	1.0262	10.2	—	1.0247	—	—	3.26	—
17	—	Do.		6	11	1.0261	10.7	—	1.02465	—	—	3.25	—
18	—	Do.		6	11	1.0258	15.6	—	1.0252	—	—	3.32	—
19	—	Do.		0	0	1.0262	10.9	—	1.0248	—	—	3.27	—
20	—	61° 25'	3° 41' E.	0	0	1.0254	16.8	—	1.0250	—	—	3.30	—
21	10	61 41.1	3 18.5	0	0	1.0253	16.2	11.5	1.0248	1.0248	—	3.27	—
22	12	61 53.3	3 0	0	0	1.0270	18.0	11.1	1.0269	1.0270	—	3.55	—
23	14	62 4	2 44.5	0	0	1.0265	19.9	9.9	1.0268	1.0271	—	3.53	—
24	14	62 4	2 44.5	226	413	1.0268	18.6	6.1	1.0268	1.0277	—	3.53	—
25	16	62 23.9	2 17	0	0	1.0275	15.4	10.9	1.02685	1.0270	—	3.54	—
26	17	62 33	2 4	0	0	1.0271	17.5	11.2	1.0269	1.0269	—	3.55	—
27	18	62 44.5	1 48	0	0	1.0270	18.4	11.6	1:0270	1.02695	—	3.56	—
28	—	62 39	2 8	0	0	1.0270	17.9	12.5	1.0269	1.0267	—	3.55	—
29	—	62 29	2 34	0	0	1.0273	16.2	12.5	1.0268	1.0266	—	3.53	—
30	19	62 23.5	2 50	0	0	1.0262	17.5	11.0	1.0260	1.02605	—	3.43	—
31	20	62 16.3	3 8	0	0	1.0256	18.7	11.2	1.0256	1.0257	—	3.38	—
32	21	62 14.7	3 27.5	0	0	1.0251	17.8	13.4	1.02495	1.02455	—	3.29	—
33	22	62 13.2	3 40.5	0	0	1.0254	18.0	12.6	1.0253	1.02505	—	3.34	—
34	—	62 52.5	5 51.5	0	0	1.0252	19.5	12.1	1.0254	1.0253	—	3.35	—
35	—	62 56	6 16	0	0	1.0253	18.4	12.8	1.0253	1.0250	—	3 34	—
36	—	Christiansund.		0	0	1.0255	17.5	—	1.0253	—	—	3.34	—
37	—	63° 10'	6° 30'	0	0	1.0260	16.2	10.0	1.0255	1.0257	—	3.36	—
38	24	63 10	5 57.5	0	0	1.0262	17.5	11.7	1.0260	1.0259	—	3.43	—
39	24	63 10	5 57.5	90	165	1.0262	17.5	6.9	1.0260	1.0267	—	3.43	—
40	—	63 10	5 19	0	0	1.0266	17.2	11.2	1.0263	1.0264	—	3.47	—
41	26	63 10	5 16	0	0	1.0261	17.6	11.8	1.0259	1.0258	—	3.41	—
42	—	63 7.1	5 17	0	0	1.0264	18.6	11.7	1.0264	1.0264	—	3.48	—
43	—	63 10	4 56	0	0	1.0264	17.5	11.6	1.0262	1.0261	—	3.46	—
44	32	63 10	4 51.3	430	786	1.0270	17.0	—0.6	1.0267	1.0281	—	3.52	—
45	—	63 9	3 56	0	0	1.0265	16.2	11.2	1.0260	1.0260	—	3.43	—
46	—	63 6	3 1	0	0	1.0260	15.8	11.8	1.0254	1.02535	—	3.35	—
47	33	63 5	3 0	525	960	1.0279	15.0	—1.1	1.0272	1.0286	—	3.59	—
48	—	63 5	2 57	0	0	1.0271	15.2	11.6	1.0264	1.0264	—	3.48	—
49	—	63 4	2 52	0	0	1.0269	14.6	12.3	1.0261	1.0259	—	3.44	—
50	—	63 3	2 43	0	0	1.0266	17.3	11.9	1.0263	1.0262	—	3.47	—
51	—	63 3	2 10	0	0	1.0275	14.3	12.0	1.02665	1.0265	—	3.52	—
52	—	63 5	1 7	0	0	1.0278	14.7	11.5	1.0270	1.0270	—	3.56	—
53	34	63 5	0 52.5	587	1073	1.0277	15.0	—1.0	1.0270	1.0284	—	3.56	—
54	—	63 3	0 54	0	0	1.0277	14.8	12.0	1.02695	1.0268	—	3.55	—
55	—	62 48	1 51	0	0	1.0273	16.3	11.9	1.0268	1.0267	—	3.53	—
56	—	62 44	2 10	0	0	1.0272	16.1	11.4	1.0267	1.0267	—	3.52	—

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.)		Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.)		Egenvægter. (Specific Gravity.)		Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.)	
				Engelske Favne. (English Fathoms.)	Meter. (Metres.)		Under Aflæsningen. (When read.)	I Havet. (In Situ) t^0	Ved $\frac{17.^0 5}{17.^0 5}$ (At $\frac{17^0 5}{17^0 5}$)	Ved $\frac{t^0}{4^0}$ (At $\frac{t^0}{4^0}$)		Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
57	—	62° 37′	2° 37′ E.	0	0	1.0277	13.1	11.5	1.0266	1.0266	—	3.51	—
58	—	62 40.5	1 58	0	0	1.0276	13.7	11.4	1.0266	1.02665	—	3.51	—
59	—	62 45	1 13	0	0	1.0277	14.6	11.4	1.0269	1.0269	—	3.55	—
60	—	63 2	1 12 W.	0	0	1.0275	15.9	11.1	1.02695	1.0270	—	3.55	—
61	—	63 3	1 14	0	0	1.0275	13.4	10.8	1.0265	1.0266	—	3.50	—
62	—	63 4	1 19	0	0	1.0277	13.2	10.8	1.02665	1.1268	—	3.52	—
63	—	63 6	1 24	0	0	1.0279	12.5	10.4	1.0267	1.0269	—	3.52	—
64	—	63 8	1 26	0	0	1.0279	12.9	10.8	1.0268	1.0269	—	3.53	—
65	—	63 12	1 26	0	0	1.0279	12.8	10.4	1.0268	1.0270	—	3.53	—
66	—	63 14	1 27	0	0	1.0278	12.8	10.5	1.0267	1.02685	—	3.52	—
67	—	63 17	1 28	0	0	1.0279	13.3	10.8	1.02685	1.0270	—	3.54	—
68	—	63 18	1 23	0	0	1.0280	11.9	10.8	1.0267	1.02685	—	3.52	—
69	—	63 45	0 57	0	0	1.0277	15.2	10.7	1.0270	1.0272	—	3.56	—
70	—	63 46	1 0	0	0	1.0277	15.2	10.2	1.0270	1.02725	—	3.56	—
71	—	63 26	1 28	0	0	1.0274	16.5	10.8	1.02695	1.0271	—	3.55	—
72	—	63 18	1 38	0	0	1.0275	16.2	10.4	1.0270	1.0272	—	3.56	—
73	—	63 8	1 58	0	0	1.0279	13.8	10.4	1.02695	1.02715	—	3.55	—
74	—	62 58	2 38	0	0	1.0279	14.0	10.2	1.0270	1.0272	—	3.56	—
75	—	62 46	3 34	0	0	1.0277	14.0	9.8	1.0268	1.0271	—	3.53	—
76	—	62 34	4 28	0	0	1.0283	11.9	9.4	1.0270	1.0274	—	3.56	—
77	—	62 20	5 28	0	0	1.0282	12.3	10.0	1.0270	1.02725	—	3.56	—
78	—	62 5	6 22	0	0	1.0278	13.8	10.6	1.02685	1.0270	—	3.54	—
79	—	Thorshavn.		0	0	1.0280	13.4	9.4?	1.0270	1.02735	—	3.56	—
80[1]	—	Do.		0	0	1.0266	10.2	9.4	1.0251	1.0254	—	3.31	—
81	—	Do.		0	0	1.0275	15.8	9.4	1.0269	1.0273	—	3.55	—
82	—	Naalsø Nordpynt. (Northern Extremity of Naalsø.)		0	0	1.0276	15.0	9.4	1.0269	1.02725	—	3.55	—
83	—	Do.		0	0	1.0277	15.0	9.4	1.0270	1.02735	—	3.56	—
84	37	62° 28′.3	2° 29′ W.	309	565	1.0276	15.3	0.1	1.0269	1.0283	—	3.55	—
85	37	62 28.3	2 29	690	1262	1.0276	15.8	—1.1	1.0270	1.0285	—	3.56	—
86	—	62 15	4 32	0	0	1.0274	15.8	9.3	1.0268	1.0272	—	3.53	—
87	—	62 23	3 26	0	0	1.0274	15.5	9.6	1.0268	1.0271	—	3.53	—
88	—	62 28	2 29	0	0	1.0274	15.7	10.4	1.0268	1.0270	—	3.53	—
89	—	62 37	2 52	0	0	1.0275	15.7	10.2	1.0269	1.0271	—	3.55	—
90	—	62 50	3 30	0	0	1.0276	15.3	10.5	1.0269	1.0271	—	3.55	—
91	—	62 57	3 47	0	0	1.0275	14.8	10.3	1.02675	1.0270	—	3.53	—
92	—	63 12	4 39	0	0	1.0274	15.7	9.7	1.0268	1.0271	—	3.53	—
93	—	63 22	5 20	0	0	1.0277	14.0	9.4	1.0268	1.0272	—	3.53	—
94	40	63 22.5	5 29	515	942	1.0277	13.6	—0.4	1.0267	1.0281	—	3.52	—
95	40	63 22.5	5 29	0	0	1.0277	13.8	9.7	1.02675	1.0271	—	3.53	—
96	40	63 22.5	5 29	0	0	1.0277	13.8	9.7	1.02675	1.0271	—	3.53	—
97	40	63 22.5	5 29	0	0	1.0277	15.4	10.3	1.02705	1.0273	—	3.57	—
98	—	Reikjavik.		0	0	1.0272	11.1	9.8	1.0258	1.0261	—	3.40	—
99	—	Midten af Faxebugt. (The Middle of Faxe Bay.)		0	0	1.0267	16.3	10.0?	1.0262	1.0265	—	3.46	—
100	—	63° 49′	22° 52′	0	0	1.0273	14.5	8.8	1.0265	1.0269	—	3.50	—
101	—	63 37	21 58	0	0	1.0274	14.2	9.7	1.0265	1.0268	—	3.50	—
102	—	63 42	22 25	0	0	1.0278	11.7	9.5	1.0265	1.0268	—	3.50	—
103	—	63 25	21 0	0	0	1.0271	15.6	10.0	1.0265	1.02675	—	3.50	—
104	—	63 13	19 54	0	0	1.0273	15.6	10.4	1.0267	1.0269	—	3.52	—
105	—	63 6	18 43	0	0	1.0273	16.8	10.6	1.0269	1.0271	—	3.55	—
106	—	63 7	17 31	0	0	1.0273	15.3	10.2	1.0266	1.02685	—	3.51	—
107	—	63 7	16 20	0	0	1.0273	15.6	11.0	1.0267	1.0268	—	3.52	—
108	—	63 8	15 9	0	0	1.0276	15.2	11.0	1.0269	1.0270	—	3.55	—
109	—	63 8	13 59	0	0	1.0279	13.0	10.7	1.0268	1.02695	—	3.53	—
110	—	63 20	13 22	0	0	1.0272	16.0	10.7	1.02665	1.0268	—	3.52	—
111	45	63 28	12 58	0	0	1.0273	16.9	10.4	1.02695	1.02715	—	3.55	—
112	—	63 38	12 35	0	0	1.0279	13.6	10.0	1.0269	1.0272	—	3.55	—

[1] Stærk Regn. (Heavy Rain.)

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.) Engelske Favne. (English Fathoms.)	Meter. (Metres.)	Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.) Under Aflæsningen. (When read.)	I Havet. (In Situ) t^0	Egenvægter. (Specific Gravity.) Ved $\frac{17.^0 5}{17.^0 5}$ (At $\frac{17^0 5}{17^0 5}$)	Ved $\frac{t^0}{4^0}$ (At $\frac{t^0}{4^0}$)	Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.) Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
113	—	63° 57′	11° 52′ W.	0	0	1.0277	13.6	10.2	1.0267	1.0269	—	3.52	—
114	—	64 14	11 12	0	0	1.0277	14.0	9.5	1.0268	1.0271	—	3.53	—
115	48	64 36	10 21.5	0	0	1.0279	11.5	5 3	1.02655	1.0275	—	3.50	—
116	—	64 44	10 4	0	0	1.0270	17 5	7.0	1.0268	1.0275	—	3.53	—
117	—	65 0	9 24	0	0	1.0269	18.0	7.4	1.0268	1.0275	—	3.53	—
118	—	65 21	8 36	0	0	1.0271	16.8	7.8	1.0267	1.0273	—	3.52	—
119	—	65 39	7 53	0	0	1.0271	15.0	7.2	1.0264	1.02705	—	3.48	—
120	51	65 53	7 18	0	0	1.0272	15.0	8.0	1.0265	1.02705	—	3.50	—
121	51	65 53	7 18	515	942	1.0272	16.0	—0.6	1.02665	1.0281	—	3.52	—
122	51	65 53	7 18	1163	2127	1.0272	16.0	—1.1	1.02665	1.0281	—	3.52	—
123	—	65 51	5 36	0	0	1.0269	18.2	8.4	1.0268	1.02735	—	3.53	—
124	—	65 49	4 18	0	0	1.0270	17.6	9.3	1.0268	1.0272	—	3.53	—
125	52	65 47.5	3 7	0	0	1.0270	17.6	9.7	1.0268	1.0271	—	3.53	—
126	52	65 47.5	3 7	515	942	1.0270	17.4	—0.4.	1.02675	1.0282	—	3.53	—
127	52	65 47.5	3 7	1861	3403	1.0280	12.0	—1.2	1.0267	1.0282	—	3.52	—
128	—	64 47	4 24 E.	0	0	1.0274	13.9	11.0	1.02645	1.02655	—	3.49	—
129	—	64 47	4 24	0	0	1.0264	19.5	11.0	1.0266	1.0267	—	3.51	—
130	—	64 49	4 46	0	0	1.0263	19.0	10.8	1.0264	1.0265	—	3.48	—
131	—	64 46	5 38	0	0	1.0270	18.0	11.2	1.0269	1.02695	—	3.55	—
132	—	64 42	6 47	0	0	1.0265	19.0	10.6	1.0266	1.0268	—	3.51	—
133	—	64 37	8 0	0	0	1.0265	19.0	10.8	1.0266	1.0267	—	3.51	—
134	—	64 27	8 36	0	0	1.0253	19.2	10.5	1.02545	1.0256	—	3.36	—
135	—	Mellem Sydhund og Revillen. Between Sydhund and Revillen.		0	0	1.0220*	15.8	—	1.0217	—	—	2.86	—
136	63	64° 41.3	9° 0′	0	0	1.0278	13.4	11.6	1.0268	1.02675	—	3.53	—
137	68	64 44.1	8 9	0	0	1.0277	13.0	11.6	1.0266	1.0266	—	3.51	—
138	73	64 46.5	7 28	0	0	1.0276	13.0	11.3	1 0265	1.0265	—	3.50	—
139	—	64 48	6 45	0	0	1.0277	13.0	11.5	1.0266	1.0266	—	3.51	—
140	—	64 48	6 26	0	0	1.0281	12.2	11.6	1.02685	1.0268	—	3.54	—
141	—	64 33	5 31	0	0	1.0278	14.2	11.8	1.0269	1.0269	—	3.55	—
142	—	64 4	5 35	0	0	1.0277	13.8	11.7	1.02675	1.0267	—	3.53	—
143	—	64 2	5 42	0	0	1.0277	13.8	12.0	1.02675	1.0267	—	3.53	—
144	89	64 1	6 7.5	0	0	1.0277	13.8	12.2	1.02675	1.0266	—	3.53	—
145	—	64 0	6 42	0	0	1.0279	12.0	11.4	1.0266	1 02665	—	3.51	—
146	—	63 48	6 42	0	0	1.0268	12.8	12.8	1.0257	1.0264	—	3.39	—
147	—	63 22	6 47	0	0	1.0259	12.8	—	1.0248	—	—	3.27	—
148	—	Stadt.		0	0	1.0250	14.2	—	1.02415	—	—	3.19	—
149	94	59° 8,2	4° 38′	0	0	1.0259	12.0	9.8	1.0245	1.0248	—	3.23	—
150	94	59 8.2	4 38	145	265	1.0263	12.0	5.0	1.0249	1.0258	—	3.28	—
151	95	60 42.5	4 13.7	0	0	1.0254	12.9	9.4	1.0242	1.0245	—	3.18	—
152	95	60 42.5	4 13.7	175	320	1.0278	11.9	5.8	1.0264	1.0272	—	3.48	—
153	—	64 47	2 50	0	0	1.0276	12.7	9.4	1.0263	1 0267	—	3.47	—
154	96	66 8.5	3 0	0	0	1,0278	13.5	8.2	1.0266	1.0272	—	3.51	—
155	96	66 8.5	3 0	805	1472	1.0275	14.9	—1.1	1.0266	1.0280	—	3.51	—
156	97	66 2	4 21	683	1249	1.0284	10.9	—1.1	1.0268	1.0283	—	3.53	—
157	98	65 56	5 21	388	710	1.0278	13.0	—1.0	1.02655	1.0280	—	3.50	—
158	99	65 51.5	6 25	213	390	1.0277	13.5	6.1	1.0265	1.0274	—	3.50	—
159	101	65 36	8 32	0	0	1.0276	12.6	9.4	1.0263	1.02665	—	3.47	—
160	101	65 36	8 32	223	408	1.0283	10.3	6.0	1.0266	1.0275	—	3.51	—
161	104	65 28	9 56	162	296	1.0282	11.4	6.5	1.0267	1.0275	—	3.52	—
162	124	66 41	6 59	0	0	1.02735	14.5	8.4	1.0264	1.0269	—	3.48	—
163	125	67 52.5	5 12	0	0	1.0282	10.1	7.0	1.0265	1.0272	1.957	3.50	3.54
164	125	67 52.5	5 12	700	1280	1.0280	10.4	—1.1	1.02635	1.0278	1.951	3.48	3.53
165	137	67 24	8 58	0	0	1.02745	9.9	8.2	1.0257	1.0263	—	3.39	—
166	137	67 24	8 58	400	732	1.0281	11.7	—1.0	1.0266	1.0281	—	3.51	—
167	143	66 58	10 33	0	0	1.0273	10.7	8.2	1.0257	1.0262	1.899	3.39	3.44
168	143	66 58	10 33	189	346	1.0279	12.0	6.2	1.0265	1.0273	1.956	3.50	3.54

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.) Engelske Favne. (English Fathoms.)	Meter. (Metres.)	Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.) Under Aflæsningen. (When read.)	I Havet. (In Situ) t^0	Egenvægter. (Specific Gravity.) Ved $\frac{17.^0 5}{17.^0 5}$ (At $\frac{17^0 5}{17^0 5}$)	Ved $\frac{t^0}{4^0}$ (At $\frac{t^0}{4^0}$)	Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.) Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
169	—	Hopen ved Bodø. (Hopen near Bodø.)		0	0	1.0091*	11.7	—	1.0083	—	—	1.09	—
170	152	67° 18′	12° 46′ E.	0	0	1.0266	14.3	8.2	1.0256	1.0261	—	3.38	—
171	152	67 18	12 46	70	128	1.0270	13.5	4.1	1 02585	1.0269	—	3.41	—
172	152	67 18	12 46	125	229	1.0274	13.5	4.1	1.0262	1.0273	—	3.46	—
173	162	68 23	10 20	795	1454	1.0270	17.2	—1.2	1.0266	1.0280	1.943	3.51	3.51
174	—	Indløbet til Hasselfjord. (Entrance to the Hassel Fjord.)		0	0	1.0269	14.5	8.8	1 0259	1.0264	—	3.41	—
175	171	69° 18′	14° 29′	0	0	1.0272	11.9	9.0	1.0258	1.0262	—	3.40	—
176	171	69 18	14 29	642	1174	1.0282	9.9	—1.0	1.0265	1.0279	—	3.50	—
177	176	69 18	14 32.7	0	0	1.0270	13.3	8.0	1.0258	1.0264	—	3.40	—
178	179	69 32	11 10	0	0	1.0280	10.9	8.8	1.0264	1.0269	1.945	3.48	3.52
179	179	69 32	11 10	1607	2939	1.0282	9 7	—1.2	1.0264	1.0279	1.935	3.48	3.50
180	183	69 59.5	6 15	0	0	1.0279	13.3	8.6	1.0267	1.0272	1.952	3.52	3.53
181	184	70 4	9 50	0	0	1.0280	12.6	7.6	1.0267	1.0273	1.943	3.52	3.51
182	184	70 4	9 50	600	1097	1.0279	12.8	0.0	1.0266	1.0280	1.928	3.51	3.49
183	184	70 4	9 50	1547	2829	1.02765	13.4	—1.3	1.0265	1.0279	1.935	3.50	3.50
184	187	69 51.5	14 41	1335	2441	1.0276	15.2	—1.1	1.02675	1.0282	1.933	3.53	3.50
185	188	69 43	15 29	0	0	1.0278	13.2	9.0	1.0266	1.0270	1.939	3 51	3.51
186	189	69 41	15 42	0	0	1.0275	13.2	9.6	1.0263	1.0266	1.923	3.47	3.48
187	189	69 41	15 42	860	1573	1.0279	12.9	—1.1	1.0266	1.0281	1.931	3.51	3.49
188	200	71 25	15 40.5	0	0	1.0282	9.9	7.8	1.0265	1.0271	—	3.50	—
189	200	71 25	15 40.5	620	1134	1.0285	9.4	—1.0	1.0267	1.0281	1.949	3.52	3.53
190	206	70 45	14 36	0	0	1.0282	9.5	8.2	1.0264	1.0270	1.945	3.48	3.52
191	206	70 45	14 36	700	1280	1.0285	8.7	—0.7	1.0266	1.0280	1.945	3.51	3.52
192	206	70 45	14 36	1248	2282	1.0283	9.2	—1.1	1.0265	1.0279	1.945	3.50	3.52
193	—	Indløbet til Malangenfjord. (Entrance to the Malangen Fjord.		0	0	—	—	—	—	—	1.744	—	3.15
194	212	70° 12.5	17° 41′	0	0	1.0255	21.7	7.2	1.0261	1.02675	1.895	3.44	3.43
195	212	70 12.5	17 41	142	260	1.0272	17.6	5.8	1.02685	1.02775	1.940	3.54	3.51
196	213	70 23	2 30	0	0	1.0277	14.2	8.2	1.0267	1.0272	1.956	3.52	3.54
197	213	70 23	2 30	1760	3219	1.0274	15.5	—1.2	1.0266	1.02805	1.951	3.51	3.53
198	215	70 53	2 0 W.	0	0	1.0276	14.9	8.0	1.0267	2.0273	1.945	3.52	3.52
199	215	70 53	2 0	200	366	1.02755	15.2	2.8	1.0267	1.0279	1.945	3.52	3.52
200	215	70 53	2 0	700	1280	1.0276	14.3	—0.6	1.0266	1.0280	1.935	3.51	3.50
201	215	70 53	2 0	1665	3045	1.0275	14.5	—1.2	1.0265	1.02795	1.939	3.50	3.51
202	217	71 0	5 8.5	0	0	1.0283	6.5	4.6	1.0262	1.0272	—	3.46	—
203	—	Østpynten af Jan Mayen. (Eastern Extremity of Jan Mayen.)		0	0	1.0280	4.0	3.0	1.02565	1.0268	—	3.38	—
204	225	70° 58′	8° 4′	0	0	1.0278	9.2	3.4	1.0260	1.0271	—	3.43	—
205	226	70 59	7 51	0	0	1.0277	10.5	3.0	1.0261	1.0272	1.893	3.44	3.42
206	226	70 59	7 51	340	622	1.0282	9.1	—0.6	1.02635	1.0278	1.936	3.48	3.50
207	—	69 20	11 18	0	0	1.0276	12.8	4.3	1.0263	1.02745	1.925	3.47	3.48
208	—	68 33	7 25	0	0	—	—	6.0	—	—	1.936	—	3.50
209	243	68 32.5	6 26	0	0	1.0280	12.8	7.8	1.0267	1.0273	1.945	3.52	3.52
210	243	68 32.5	6 26	600	1097	1.02715	16.7	—0.8	1.0266	1.0280	1.927	3.51	3.49
211	243	68 32.5	6 26	1385	2533	1.0286	5.7	—1.3	1.0264	1.0278	1.940	3.48	3.51
212	245	68 21	2 5	0	0	1.0280	13.4	9.0	1.0268	1.02725	—	4.53	—
213	247	68 5.5	2 24 E.	0	0	1.0278	13.8	9.4	1.0267	1.0271	1.954	3.52	3.53
214	247	68 5.5	2 24	500	914	1.0278	13.1	—0.4	1.0266	1.0280	1.927	3.51	3.49
215	247	68 5.5	2 24	1120	2048	1.0275	14.5	—1.2	1.0265	1.02795	1.929	3.50	3.49
216	249	68 12	6 35	1063	1944	1.0274	15.4	—1.3	1.0266	1.0280	1.937	3.51	3.50
217	251	68 6.5	9 44	0	0	1.0276	13.9	13.2	1.0265	1.0262	1.927	3.50	3.49
218	252	Søndenfor Skraaven. (South of Skraaven.)		0	0	1.0254	19.2	14.0?	1.0254	1.0249	1.820	3.35	3.29
219	253	Skjærstadfjord.		0	0	1.0178*	14.4	13.0	1.0173	1.0168	1.261	2.28	2.28
220	253	Do.		263	481	1.02755	11.2	3.2	1.0260	1.02715	1.887	3.43	3.41
221	254	67° 27′	13° 25′	0	0	1.0266	12.6	10.0	1.0253	1.0255	1.843	3.34	3.33
222	254	67 27	13 25	70	128	1.0278	11.2	4.8	1.02625	1.0272	1.929	3.46	3.49
223	254	67 27	13 25	140	256	1.0281	12.1	5.8	1.0267	1.0276	1.931	3.52	3.49
224	—	Frohavet.		0	0	1.0262	12.0	—	1.0248	—	1.822	3.27	3.29

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.) Engelske Favne. (English Fathoms.)	Meter. (Metres.)	Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.) Under Aflæsningen. (When read.)	I Havet. (In Situ) t°	Egenvægter. (Specific Gravity.) Ved 17.°5/17.°5 (At 17°5/17°5)	Ved t°/4° (At t°/4°)	Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.) Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
225	255	68° 12.'3	15° 40' E.	0	0	1.0262	14.3	10.7	1.0252	1.0253	—	3.32	—
226	255	68 12.3	15 40	300	549	1.0280	12.9	6.5	1.0267	1.0275	—	3.52	—
227	256	70 8.5	23 4	0	0	—	—	—	—	—	1.118.	—	2.02
228	256	70 8.5	23 4	225	411	1.0280	10.9	4.0	1.0264	1.0275	1.930	3.48	3.49
229	258	70 12.6	23 2.5	0	0	1.0276	8.3	11.6	1.0257	1.0256	1.865	3.39	3.37
230	258	70 12.6	23 2.5	230	421	1.0282	6.9	4.0	1 0261	1.0272	1.907	3.44	3.45
231	259	70 48.9	25 59	80	146	1.0286	6.7	4.1	1.02645	1.0275	1.942	3.49	3.51
232	261	70 47.5	28 30	0	0	1.0248	11.9	7.4	1.0234	1.0240	1.713	3.09	3.10
233	261	70 47.5	28 30	127	232	1.0280	10.9	2.8	1.0264	1.0276	1.920	3.48	3.47
234	262	70 36	32 35	0	0	1.0282	8.5	5.6	1.0263	1.0272	1.921	3.47	3.47
235	262	70 36	32 35	148	271	1.0284	8.9	1.9	1.0265	1.0278	1.932	3.50	3.49
236	263	70 44.5	34 14	121	221	1.1286	6.9	1.9	1.0265	1.02775	1.927	3.50	3.49
237	264	70 56	35 37	0	0	1.0279	11.3	5.2	1.0264	1.0273	1.929	3.48	3.49
238	264	70 56	35 37	86	157	1.0281	11.4	1.9	1.0266	1.02785	1.934	3.51	3.50
239	268	71 36.5	36 18	0	0	1.0284	8.7	4.4	1.0265	1.02755	1.925	3.50	2.48
240	268	71 36.5	36 18	130	238	1.0285	8.9	—1.0	1.0266	1.0281	1.938	3.51	1.51
241	270	72 27.5	35 1	0	0	1.0284	9.0	3.6	1.02655	1.0277	1.937	3.50	1.50
242	270	72 27.5	35 1	136	249	1.0286	8.9	0 0	1.0267	1.0281	1.937	3.52	3.50
243	272	73 10.8	33 3	113	207	1.0285	8 9	1.5	1.0266	1.0279	1.937	3.51	3.50
244	273	73 25	31 30	0	0	1.0285	8.7	4.9	1.0266	1.0276	1.938	3.51	3.51
245	273	73 25	31 30	197	360	1.0285	8.5	2.2	1.0266	1.0278	1.943	3.51	3.51
246	275	74 8	31 12	0	0	1.0287	5.9	2.9	1.0265	1.0277	1.935	3.50	3.50
247	275	74 8	31 12	147	269	1.0289	5.5	—0.4	1.02665	1.02805	1.936	3.52	3 50
248	278	74 1.5	22 27	0	0	1.0286	5.9	4.2	1.0264	1.02745	—	3.48	—
249	278	74 1.5	22 27	230	421	1.0287	5.3	0.9	1.0264	1.0278	—	3.48	—
250	280	74 10.5	18 51	0	0	1.0282	9.3	1.2	1.0264	1.0277	—	3.48	—
251	280	74 10.5	18 51	35	64	1.0283	9.4	1.1	1.0265	1.0278	—	3.50	—
252	281	74 3	17 18	0	0	1.0285	8.9	4.6	1.0266	1.02765	1.967	3.51	3.56
253	281	74 3	17 18	115	210	1.0287	8.8	2.2	1.0268	1.0281	1.939	3.53	3.51
254	283	73 47.5	14 21	0	0	1.0282	11.3	7.2	1.0267	1.0274	1.938	3.52	3.51
255	284	73 1	12 58	0	0	1.0283	11.2	6.8	1.02675	1.0275	1.940	3.53	3.51
256	286	72 57	14 32	447	817	1.0284	9.5	—0.8	1.0266	1.02805	—	3.51	—
257	289	72 41.5	20 18	0	0	1.0282	11.1	7.6	1.02665	1.0273	—	3.52	—
258	289	72 41.5	20 18	219	400	1.0282	11.1	2.0	1.02665	1.0279	—	3.52	—
259	291	71 54	21 57	0	0	1.0280	12.0	7.4	1.0266	1.02725	1.936	3.51	3.50
260	291	71 54	21 57	194	355	1.0284	10.5	3.0	1.02675	1.02795	1.944	3.53	3.52
261	293	71 7	21 11	0	0	1.0272	5.0	—	1.02495	—	1.909?	3.29	3.45
262	293	71 7	21 11	95	174	1.0276	5.3	—	1.0254	—	1.943	3.35	3.51
263	294	71 35	15 11	0	0	1.0272	4.9	—	1.02495	—	1.918	3.29	3.47
264	294	71 35	15 11	637	1165	1.0284	7.1	—1.2	1.0263	1.02775	1.934	3.47	3.50
265	295	71 59	11 40	0	0	1.0278	13.5	7.0	1.02665	1.02735	1.942	3.52	3.51
266	295	71 55	11 30	100	183	1.0283	10.1	3.2	1.0266	1.0278	1.942	3.51	3.51
267	295	71 55	11 30	600	1097	1.0281	10.7	—0.8	1.0265	1.0279	1.936	3.50	3.50
268	295	71 59	11 40	1110	2030	1.0278	13.3	—1.3	1.0266	1.02805	1.934	3.51	3.50
269	296	72 15.5	8 9	100	183	1.0286	7.1	3.1	1.0265	1.0277	1.944	3.50	3.52
270	296	72 15.5	8 9	600	1097	1.0287	7.1	—0.5	1.0266	1.0280	1.939	3.51	3.51
271	297	72 36.5	5 12	0	0	1.0284	5.9	4.8	1.0262	1.0272	1.928	3.46	3.49
272	297	72 36.5	5 12	1280	2341	1.0286	5.0	—1.4	1.0263	1.02775	1.926	3.47	3.48
273	298	72 52	1 50.5	0	0	1.0272	15.1	4.0	1.0263	1.0274	1.917	3.47	3.47
274	298	72 52	1 50.5	1500	2743	1.0271	16.8	—1.5	1.0266	1.0280	1.915?	3.51	—
275	299	73 10	2 14 W.	0	0	1.0269	13.7	3.6	1.0258	1.0269	1.888	3.40	3.42
276	300	73 10	3 22	0	0	1.0255	15.2	1.7	1.0247	1.0259	1.810	3.26	3.27
277	301	74 1	1 20	0	0	1.0263	14.3	2.2	1.0253	1.0265	1.837	3.34	3.32
278	302	75 16	0 54	0	0	1.0285	7.9	3.0	1.0265	1.0277	1.920	3.50	3.47
279	303	75 12	3 2 E.	0	0	1.0283	6.5	3.3	1.02615	1.0273	1.914	3.45	3.46
280	303	75 12	3 2	150	274	1.0288	4.4	—1.1	1.02645	1.0279	1.929	3.49	3.49

No.	Stat. No.	Nordlig Bredde. (North Latitude.)	Længde fra Greenwich. (Longitude from Greenwich.)	Dybde hvorfra Prøven hentet. (Depth from which the Samples were collected.) Engelske Favne. (English Fathoms.)	Meter. (Metres.)	Aflæste Egenvægter. (Specific Gravity read.)	Temperatur. (Temperature.) Under Aflæsningen. (When read.)	I Havet. (In Situ.) t^0	Egenvægter. (Specific Gravity.) Ved $\frac{17.^05}{17.^05}$ (At $\frac{17.^05}{17.^05}$)	Ved $\frac{t^0}{4^0}$ (At $\frac{t^0}{4^0}$)	Chlormængde. (Amount of Chlorine.)	Saltmængde. (Amount of Salt measured.) Efter Aræometer. (By the Areometer.)	Efter Chlormængde. (By the Amount of Chlorine.)
281	304	75° 3'	4° 51' E.	300	549	1.0273	14.9	—0.8	1.0264	1.0278	1.929	3.48	3.49
282	304	75 3	4 51	1735	3173	1.0273	14.5	—1.5	1.0263	1.02775	1.940	3.47	3.51
283	305	75 1.5	7 56	0	0	1.0272	14.8	5.3	1.0263	1.0272	1.947	3.47	3.52
284	306	75 0	10 27	0	0	1.0275	14.1	5.4	1.02645	1.0274	1.929	3.49	3.49
285	306	75 0	10 27	1334	2440	1.0272	14.9	—1.3	1.0263	1.0277	1.920	3.47	3.47
286	310	74 56	13 50	0	0	1.0274	14.7	5.5	1.02645	1.0274	1.936	3.49	3.50
287	310	74 56	13 50	1006	1840	1.0275	13.8	—1.4	1.0264	1.0278	1.932	3.48	3.49
288	316	74 56	16 29	0	0	1.0269	14.7	3.6	1.02595	1.02705	1.903	3.42	3.44
289	316	74 56	16 29	129	236	1.0275	14.6	1.9	1.02655	1.0278	1.930	3.50	3.49
290	321	74 56.5	19 30	25	46	1.0275	9.7	0.2	1.02575	1.0271	—	3.40	—
291	323	72 53.5	21 51	0	0	1.0283	9.7	7.8	1.02655	1.0272	1.947	3.50	3.52
292	323	72 53.5	21 51	223	408	1.0284	8.9	1.5	1.0265	1.0278	1.933	3.50	3.50
293	326	75 31.5	17 50	0	0	1.0276	8.9	4.8	1.02575	1.0267	1.904	3.40	3.44
294	326	75 31.5	17 50	123	225	1.0284	8.7	1.6	1.0265	1.0278	1.930	3.50	3.49
295	328	75 42	15 39	0	0	1.0279	9.9	4.7	1.0262	1.0272	1.908	3.46	3.45
296	328	75 42	15 39	200	366	1.0282	9.8	—1.3	1.02645	1.0279	1.942	3.49	3.51
297	331	75 51	13 5	0	0	—	—	—	—	—	1.935	—	3.50
298	332	75 56	11 36	1149	2101	1.0286	6.3	—1.5	1.0264	1.0279	—	3.48	—
299	334	76 12.5	14 0	0	0	1.0275	13.7	6.0	1.0264	1.0272	1.923	3.48	3.48
300	334	76 12.5	14 0	403	737	1.0277	13.7	1.0	1.0266	1.0279	1.935	3.51	3.50
301	335	76 16.5	14 39	0	0	1.0270	15.5	5.4	1.0262	1.0271	1.914	3.46	3.46
302	335	76 16.5	14 39	179	327	1.0276	13.4	1.0	1.0264	1.0277	1.940	3.48	3.51
303	339	76 30	15 39	0	0	1.0267	12.7	2.6	1 0254	1.0266	1.867	3.35	3.38
304	339	76 30	15 39	37	68	1.0273	13.6	0.9	1.02615	1.0275	1.924	3.45	3.48
305	342	76 33	13 18	0	0	1.0277	12 4	6.2	1.02635	1.0272	1.936	3.48	3.50
306	342	76 33	13 18	523	956	1.0277	12.2	—1.0	1.0263	1.0277	1.933	3.47	3.50
307	344	76 42	11 16	0	0	1.0283	6.2	5.2	1.0261	1.0271	—	3.44	—
308	347	76 40.5	7 47	0	0	1.0277	11.3	4.4	1.0262	1.0272	1.924	3.46	3.48
309	347	76 40.5	7 47	1429	2613	1.0278	11.6	—1.3	1.0263	1.02775	1.935	3.47	3.50
310	349	76 30	2 57	0	0	1.0274	11.2	3.8	1.02585	1.0269	1.898	3.41	3.43
311	349	76 30	2 57	1487	2719	1.0277	11.3	—1.5	1.0262	1.0276	1.946	3.46	3.52
312	350	76 26	0 29 W.	0	0	1.0270	10.9	3.0	1.0254	1.0266	1.872	3.35	3.39
313	350	76 26	0 29	300	549	1.0279	10.9	—1.1	1.0263	1.02775	1.922	3.47	3.48
314	350	76 26	0 29	1686	3083	1.0276	10.8	—1.5	1.0260	1.0274	1.916	3.43	3.47
315	352	77 56	3 29 E.	0	0	1.0272	12.8	3.9	1.0259	1.0270	1.908	3.41	3.45
316	352	77 56	3 29	300	549	1.0274	14.0	—0.8	1.0263	1.02775	1.928	3.47	3.49
317	355	78 0	8 32	0	0	1.0275	10.3	4.9	1.0258	1.0268	1.890	3.40	3.42
318	355	78 0	8 32	948	1734	1.0280	9.9	—1.3	1.0263	1.0277	1.927	3 47	3.49
319	357	78 3	11 18	0	0	1.0261	10 9	5.0	1.02455	1.02545	1.797	3.24	3.25
320	359	78 2	9 25	0	0	1.0280	5.3	4.3	1.02575	1.0268	—	3.40	—
321	359	78 2	9 25	416	761	1.0276	13.7	0.8	1.0265	1.0278	1.925	3.50	3.48
322	361	79 8.5	5 28	0	0	1.0278	11.5	4.2	1.0263	1.02735	1.906	3.47	3.45
323	361	79 8.5	5 28	905	1655	1.0272	12.9	—1 2	1.02595	1.02705	1.928	3.42	3.49
324	362	79 59	5 40	0	0	1.0274	13.0	5.2	1.02615	1.0271	1.917	3.45	3.47
325	362	79 59	5 40	459	839	1.0275	12.8	—1.0	1.0262	1.0276	1.922	3.46	3.48
326	363	80 0	8 15	0	0	1.0276	10.9	4.6	1.0260	1.0270	—	3.43	—
327	363	80 0	8 15	260	475	1.0284	7.7	1.1	1.0264	1.0277	1.945	3.48	3.52
328	—	Ved Norskøerne. (The Norsk Islands.)		0	0	1.0283	4.1	2.7	1.02595	1.0271	—	3.42	—
329	—	Magdalenebay.		0	0	1.0268	12.3	2.2	1.02545	1.0266	—	3.36	—
330	368	78° 43'	8° 20'	0	0	1.0266	13.0	4.6	1.0254	1.02635	—	3.35	—
331	368	78 43	8 20	315	576	1.0286	8.5	1.6	1.0267	1.0280	1.936	3.52	3.50
332	—	78 34	9 22	0	0	1.0262	11.9	4.5	1.0248	1.0258	—	3.27	—
333	372	78 9	14 12	0	0	1.0258	5.0	4.1	1.0236	1.0246	—	3.11	—
334	373	78 10	14 26	0	0	1.0250	12.5	4.0	1.0237	1.0247	—	3.13	—
335	—	Mundingen af Adventbay. (Entrance to Advent Bay.)		0	0	1.0250	5.3	4.7	1.02285	1.0237	—	3.01	—

Af denne Tabel fremgaar det, at Differentserne mellem de ved Hjælp af Egenvægt og Chlormængde beregnede Saltmængder i Regelen ere meget smaa, kun de 3 samtidig udførte Bestemmelser i Vandprøverne No. 261, 262 og 263 danne i saa Henseende en Undtagelse. De store her optrædende Differentser skyldes uden Tvivl en Feil ved Aflæsningen af Egenvægterne, som for disse Vandprøvers Vedkommende ere fundne altfor lave, til at de kunne bringes i Harmoni med andre paa Steder i Nærheden udførte Observationer. Det er saaledes i høi Grad paafaldende for Vandprøven No. 262, optagen fra et Dyb af 95 Favne (174 Meter) i ca. 8 Miles Afstand fra Land, at finde Egenvægten 1.0254, medens man i de indenfor liggende Fjorde, hvor Saltgehalten ellers overalt er mindre end paa Havet, i lignende Dyb finder en meget større Egenvægt. Selv i den indelukkede Skjærstadfjord, hvor Overfladevandet er særdeles fattigt paa Salte, er dog Egenvægten paa Bunden funden at være 1.026, kort sagt, Egenvægter som de i de omtalte Tilfælde observerede staa paa dette Strøg af Kysten fuldstændig uden Sidestykke. Naturligst lade disse Urimeligheder sig forklare ved at antage Egenvægterne aflæste med 0.001 for lavt, da de ved denne Antagelse paa det Nærmeste kan bringes i Overensstemmelse saavel med de i de samme Vandprøver udførte Chlorbestemmelser som med de andre Observationer fra nærliggende Puncter.

Bortser man fra disse 3 nævnte Observationer og af de øvrige beregner den gjennemsnitlige halve Differents mellem to paa samme Vandprøve ved Hjælp af Chlortitrering og Aræometer udførte Saltbestemmelser, resulterer som Udtryk for denne 0.00904, eller man erholder under Forudsætning af, at Feilene i lige høi Grad skyldes Chlor- som Egenvægtsbestemmelserne, for den gjennemsnitlige Feil af en Egenvægtsbestemmelse Værdien 0.000069 og af en Chlorbestemmelse 0.005. Differentserne falde, som man ser, snart til den ene snart til den anden Side, idet det dog maa bemærkes, at Chlormængden gjennemsnitlig giver lidt over 0.008 % høiere Saltgehalt end Egenvægterne, hvad der næsten udelukkende skyldes de nordenfor den 75de Breddegrad udførte Observationer.

Førend jeg nu gaar over til at give en Oversigt over de Resultater, som af disse Observationer lader sig udlede, vil det være nødvendigt parenthetisk at indskyde nogle Bemærkninger om Dybde- og Temperaturforholdene i det norske Hav i sine groveste Træk. Hvad der til den Ende her meddeles, er hovedsagelig hentet fra en af Professor Dr. Mohn forfattet Afhandling, som findes trykt i C. F. Schübelers "Væxtlivet i Norge."

Dybden i det af den norske Expedition undersøgte Hav, forsaavidt det ligger vestenfor en Linie fra Spitsbergen til det nordlige Norge, er i større Afstand fra Land overalt over 1000 Favne (1829 Meter) og gaar i Regelen op til mellem 1500 og 2000 Favne (2743 og 3658 Meter) eller endog derover. Paa Strøget mellem Beeren Eiland og Jan Mayen hæver sig en Ryg, hvor Dybden ikke naar 1500 Favne (2743 Meter), medens der saavel søndenfor

This Table shows the differences in the amount of salt computed from specific gravity and the proportion of chlorine to be, as a rule, exceedingly small, the 3 determinations performed successively with samples Nos. 261, 262, and 263 constituting the sole exception. The great differences observed here must unquestionably arise from erroneous readings of the specific gravity, which, as found for these samples, is much too low when compared with that determined for others obtained from adjacent localities. Thus, for instance, the specific gravity of sample No. 262, drawn at a depth of 95 fathoms (174 metres), about 8 geographical miles from land, is stated to be 1.0254, whereas that determined for the water of the neighbouring fjords, in which the amount of salt at equal depths is invariably less than in the open sea, was much greater. Even for a frith locked in as is the Skjærstadfjord, where the surface-water is remarkably deficient in salts, the specific gravity of bottom-samples was found to be 1.0260; in short, such exceptional specific gravities are without a parallel on this line of coast. The most natural explanation of these incongruities, is afforded by assuming the specific gravity in each case to have been read 0.001 too low; the results could then be made to agree pretty closely both with the chlorine-determinations performed with the same samples of water and with observations taken in adjacent localities.

Now, if we disregard the 3 exceptional observations, and for the others compute the average half-difference between two salt-determinations performed with the same sample of water by means of the areometer and titrating with chlorine, this will be expressed by 0.00904; or, assuming the errors to lie equally in the chlorine and the specific gravity determinations, the mean error of a specific gravity determination is 0.000069, and of a chlorine-determination 0.005. As will be seen, the differences between the 2 right-hand columns of the Table are sometimes positive, sometimes negative; but the amount of salt indicated by the proportion of chlorine exceeds on an average that denoted by the specific gravity by a trifle over 0.008 per cent, which must be referred almost exclusively to the observations taken north of the 75th parallel of latitude.

Before proceeding to review the results deducible from these observations, it will be necessary to interpolate a few general remarks on the depth and temperature of the Norwegian Sea. To this end, I shall merely recapitulate what Professor Mohn has stated on the subject in a Memoir printed in C. F. Schübeler's "Væxtlivet i Norge."

The depth of the Sea investigated by the Norwegian North-Atlantic Expedition was found to be as follows: — Throughout the tract extending west of an imaginary line drawn from Spitzbergen to the northern extremity of Norway, it is never less than 1000 fathoms (1829 metres) some considerable distance from land, and generally ranges from 1500 to 2000 fathoms (2743—3658 metres); nay, in some places it is even greater. Between Beeren Ei-

som nordenfor findes betydelig større Dyb paa indtil over 2000 Favne (3658 Meter). Østhavet, det vil sige Havet østenfor en Linie fra Spitsbergen til det nordlige Norge, er overalt meget grundt, da Dybden der paa faa Steder overskrider 200 Favne (366 Meter).

De talrige udførte Temperaturobservationer vise, at Vandet i den af Expeditionen undersøgte Del af Østhavet med Undtagelse af den østligste og nordligste Strækning holder Varmegrader ligefra Overfladen til Bunden, saaledes som dette ogsaa er Tilfælde med Vandet paa de norske Banker, som paa enkelte Steder strækker sig ud til en ikke ubetydelig Afstand fra Kysten. Helt anderledes er Forholdet i det vestenfor liggende dybere Hav, som med Hensyn paa Temperaturforholdene naturlig kan inddeles i 2 Hovedstrøg, den i den østlige Del nordover gaaende saakaldte Golfstrøm og den i den vestlige Del sydover gaaende østgrønlandske Polarstrøm. Grændsen mellem disse gaar nordenom Island op til Jan Mayen, bøier i en Bue søndenom og østenom denne og overskrider paa omkring 3° vestlig Længde med nordostlig Retning den 71de Breddegrad. Herfra gaar den mod Øst til henimod 7° østlig Længde og fortsætter derfra i nordlig og lidt vestlig Retning til nordenom den 80de Breddegrad.

I den østenfor denne Grændse beliggende Del af Havet besidder Overfladevandet en forholdsvis høi Temperatur, der endog overskrider Luftens midt om Sommeren, hvorhos ogsaa Vandet i de nærmest under Overfladen beliggende Lag holder Varmegrader, saaledes at 0° først forefindes i et Dyb af omkring 500 Favne (914 Meter), hvorfra Temperaturen jevnt og langsomt synker til omkring —1.°3 ved Havbunden.

I den østgrønlandske Koldvandsstrøm er derimod Temperaturen i selve Overfladen meget lav men om Sommeren i isfrit Vand dog overalt over 0°, medens den allerede fra faa Favnes Dyb og nedover lige til Bunden holder sig under 0°.

Med Hensyn paa Saltgehalten i Overfladevandet henvises til Kartet No. I, hvori findes indtegnet en større Del af de Tal, der fremgaa som Middel af de efter Chlor- og Egenvægtsbestemmelserne beregnede Værdier for Saltmængden. Efter disse Observationer findes ogsaa optrukket Grændserne for 3.55, 3.50, 3.45 og 3.40 °/₀ Salt, saaledes som deres Form maa antages at være i Sommermaanederne. Kartet viser, at den i Syd ind i det norske Hav strømmende Varmvandsstrøm fører Vand af temmelig stor Saltgehalt, som i de sydligste Egne paa begge Sider af Færøerne gaar op til 3.55 °/₀ eller endog derover. Herfra gaar Strømmen videre i nordostlig Retning med noget lavere Saltgehalt (omkring 3.525 °/₀) indtil henimod Beeren Eiland, hvor den deler sig og sender en Arm mod Øst ind i Østhavet og en anden i nordlig og noget vestlig Retning

land and Jan Mayen there is a vast ridge, and here the depth does not reach 1500 fathoms (2743 metres); but south and north of that ridge it is much greater, in some localities more than 2000 fathoms (3658 metres). Barents' Sea, or the tract of ocean stretching between Novaja Zemlja and an imaginary line drawn from Spitzbergen to the northern extremity of Norway, is everywhere exceedingly shallow, the depth in but few places reaching above 200 fathoms (366 metres).

The extensive series of observations shows that the temperature of the water throughout the part of Barents' Sea investigated by the Expedition, saving the most easterly and northerly tracts, exhibits everywhere a temperature above zero, from the surface to the bottom, as is also the case with the water on the great Norwegian banks, which, in certain localities, extend to a considerable distance from the coast. A very different relation rules in the deep western section, which, as regards temperature, may be divided into two principal tracts, an eastern, with the Gulf Stream, as it is called, flowing north, and a western, with the Arctic current, flowing south, along the shores of East Greenland. The boundary-line between these two currents extends north of Iceland to the island of Jan Mayen, where it makes a bend southward and eastward, crossing, in longitude about 3° W., with a north-easterly direction, the 71st parallel of latitude. From thence it runs east, and, when in longitude about 7° E., takes a northerly and somewhat westerly direction, continuing on past the 80th parallel of latitude.

In the tract of ocean stretching to the east of this boundary, the temperature of the surface-water is comparatively high, exceeding even that of the atmosphere in the middle of summer; the water, too, some distance below the surface exhibits a temperature above zero, the depth at which 0° is reached being about 500 fathoms (914 metres), from which the temperature sinks slowly and gradually to about —1.°3, at the bottom.

In the cold East Greenland current, the temperature at the surface is on the other hand exceedingly low, though in summer above zero where the water is free from ice; 0° however is reached at the depth of a few fathoms.

As regards the amount of salt in the surface-water, the reader is referred to Plate I, in which will be found most of the figures representing the mean values, deduced from the chlorine and specific gravity-determinations, for the proportion of salt. In Pl. I, too, are laid down curves constructed from these results, to show the limits of distribution for the following percentages of salt: 3.55, 3.50, 3.45, and 3.40, as they may be assumed to extend in the summer months. The warm current, flowing from the south into the Norwegian Sea, brings with it, as shown by the Plate, an indraught of water containing a comparatively large amount of salt, the maximum percentage, upwards of 3.55, being reached in the most southerly tracts, along the eastern and western shores of the Feröe Islands. From thence, with a slightly reduced amount of salt (about 3.525), the

forbi Spitsbergens Vestkyst. I den mod Øst gaaende Gren synker Saltgehalten meget langsomt og jevnt, indtil den ved Grændsen af det af Expeditionen undersøgte Felt har naaet 3.50 %, medens den i den nordover flydende Arm meget hurtigt synker til endog under 3.45 % for atter ved Spitsbergens Nordvestkyst at hæve sig til lidt over 3.45 %.

Denne i Vest for Spitsbergen forefundne ringe Saltholdighed i Overfladen er dog sandsynligvis kun eiendommelig for den varmere Aarstid, da der fra Spitsbergens mægtige Is- og Snebræer flyder store Mængder Ferskvand ned i det tilstødende Hav.

Indflydelsen af saadant fra Kysterne udgaaende Ferskvand indskrænker sig dog hovedsagelig kun til meget smaa Dyb, da det saavel af disse som tidligere publicerede Undersøgelser af samme Art fremgaar, at et over saltere Vand flydende ferskere Overfladelag besidder en mærkelig Evne til meget længe at holde sig forholdsvis ublandet, saaledes at den fra Kysterne hidrørende Fortynding i Overfladen ofte kan spores 30 til 40 Mile tilhavs, medens man ved Bunden i Nærheden af Land ja endog i Fjordene kan finde meget saltholdigt Vand. Denne Eiendommelighed træder meget skarpt frem i Observationsrækken No. 1 til 8,[1] da Saltgehalten her fra Overfladen til 1 Favns (2 Meters) Dyb tiltager med over 1 %, medens den siden temmelig jevnt voxer med kun 0.06 % for hver Favns Tilvæxt af Dybden. De paa Spitsbergens Banker tagne Observationer viser da ogsaa ganske rigtigt, at Vandet der paa Bunden i nogen Afstand fra Land besidder en Saltstyrke, som paa sine Steder endog gaar op til over 3.50 %.

Paa begge Sider af den midt efter det norske Hav flydende salte Overfladestrøm synker Saltgehalten paa den ene Side mod den norske Kyst og paa den anden Side mod den østgrønlandske Polarstrøm, en Synkning, som paa Grund af de herskende Strømforholde hverken er jevn eller regelmæssig. Saaledes flyder der fra Nordsøen langs Norges Vestkyst i nordlig Retning en lidet saltholdig Overfladestrøm, som ved den 62de Breddegrad, hvor Kysten bøier nordostover, forlader denne, og fortsætter fremdeles i nordlig Retning, indtil dens Virkninger i omtrent 40 Miles Afstand fra Land efterhaanden taber sig. En mindre udpræget lignende Kyststrøm gaar fra Vestfjorden udover i sydvestlig Retning og naar ligeledes temmelig langt tilhavs, førend dens Indflydelse paa Saltgehalten i Overfladevandet fuldstændig forsvinder. Mellem disse Kyststrømme kaster der sig en smal Arm af det saltere Atlanterhavsvand forholdsvis nær ind under Land, hvor den meget skarpt

[1] Disse Observationer kunne desuden ogsaa tjene som Bevis for Fortrinligheden af den af Ekman angivne Vandhenter, som ved denne Leilighed benyttedes.

current flows in a north-easterly direction, as far north almost as Beeren Eiland, where it divides into two arms, one running east into Barents' Sea, and the other in a north-westerly direction past the west coast of Spitzbergen. In the branch flowing east, the amount of salt diminishes very slowly and gradually down to 3.50 per cent, at the limit of the region explored by the Expedition, whereas in that running north it rapidly sinks even below 3.45 per cent, rising, however, on the north-western coast of Spitzbergen a little above 3.45 per cent.

This low percentage of salt in the surface-water west of Spitzbergen is, however, in all probability the result of summer heat, vast quantities of freshwater pouring down to the sea at that season of the year from the immense glaciers and snow-fields of that group of islands.

The effect of such an influx of fresh water from the coast is, however, mostly confined to a very trifling depth, the result of the observations taken on the Expedition, and of others in connexion with the same subject previously published, being to show, *inter alia,* that freshwater possesses the remarkable property of floating on salt water for some considerable time in a comparatively unmixed state, so that its influence may be frequently traced at a distance of from 30 to 40 geographical miles off shore, whereas the bottom-water close in shore, nay that of friths and estuaries even, often contains a very large proportion of salt. This peculiar feature was strikingly instanced in the series of observations from No. 1 to 8,[1] the amount of salt at the depth of 1 fathom (2 metres) exceeding that at the surface by 1 per cent, whereas the subsequent increase with the depth did not amount to more than 0.06 per cent for every fathom. The observations taken on the banks of Spitzbergen show that the maximum percentage of salt in the bottom-water some distance from land, in certain localities, reaches 3.50.

On either side of the salt surface-current flowing through the medial portion of the Norwegian Sea, the amount of salt diminishes, eastward in the direction of the Norwegian coast and westward in the direction of the Arctic current off East Greenland; but this diminution, owing to the effect of ocean currents, is however anything but regular and gradual. Thus, for instance, a surface-current, with a low percentage of salt, flows from the North Sea in a northerly direction along the west coast of Norway, from which it diverges near the 62nd parallel of latitude, continuing on, still in a northerly direction, till, about 40 geographical miles from land, its influence gradually ceases to be felt. Another coastal current, more limited in extent, flows from the Vestfjord in a south-westerly direction, its influence on the amount of salt in the surface-water being likewise perceptible comparatively far out at sea. Between these coastal currents runs a narrow arm

[1] These observations likewise attest the excellence of Ekman's apparatus for collecting sea-water, which was used on this occasion.

afgrændser sig mod det indenfor flydende meget ferskere Vand. Forøvrigt holder Grændsen for det saltere Overfladevand sig meget langt tilhavs med Undtagelse af, at den ved den 70de Breddegrad paa en ganske kort Strækning kaster sig tæt ind under Kysten.

Denne Fortynding af Overfladevandet, som overalt ytrer sig ved den norske Kyst, er intetsteds ledsaget af nogen væsentlig Forrykkelse af Overfladetemperaturen. Saltgehaltens Formindskelse skyldes her aabenbart det fra Kysterne udstrømmende Flodvand, der om Sommeren besidder en ikke ringe Varmegrad, saaledes at man i den mest fremtrædende Kyststrøm langs Norges Vestkyst endog finder en noget høiere Overfladetemperatur end paa nærliggende Puncter. Ganske anderledes stiller Sagen sig paa den mod den østgrønlanske Polarstrøm vendende Side, hvor Overfladevandet fortyndes ikke ved Flodvand men ved det ved Havisens Smeltning dannede, stærkt afkjølede Ferskvand, og det viser sig derfor, at en Synken i Saltgehalten her bestandig er ledsaget af en tilsvarende Formindskelse af Overfladetemperaturen. Grændsen for det saltere Vand i Overfladen følger derfor paa denne Side ofte Polarstrømmens Grændse, og selv der, hvor den forlader denne, optræder der dog samtidig med Overgangen fra saltere til ferskere Vand altid meget tydelige Variationer i Temperaturen, der gaa i samme Retning som Saltgehaltens. At Overfladetemperaturen synker, naar man enten nærmer sig eller overskrider Grændsen for 3.50 % Salt, vise Observationerne No. 115 til 120 og No. 207 til 209.

I selve Polarstrømmen er Saltgehalten i Overfladen i nogen Afstand fra Grændsen oftest fundet meget lav, kun paa et Sted optræder i saa Henseende en Undtagelse fra den almindelige Regel, idet der omtrent paa den 75de Breddegrad skyder sig en smal Tunge med Vand af høiere Saltstyrke ind over Polarstømmen, uden at der dog derved bevirkes nogen væsentlig Forhøielse af Overfladetemperaturen. En Mærkelighed, som fortjener at omtales, er den, at Professor Dr. G. O. Sars, som paa Expeditionens Togter jevnlig undersøgte Dyrelivet i Overfladen, netop paa dette Punct langt inde i Polarstrømmen har gjenfundet de for det varmere Atlanterhavsvand eiendommelige Dyreformer, der forresten intetsteds ellers ere fundne i den østgrønlandske Koldvandsstrøm.

Med Hensyn paa Saltmængderne i de større Dyb henvises til Kartet No. II, hvori paa samme Maade som ovenfor findes indtegnet Saltgehalten ved Havbunden samt i de intermediære Dyb, forsaavidt Observationerne refererer sig til Puncter saa dybt under Overfladen, at Temperaturen der ligger under 0°. Hvor en Observation hidrører fra et intermediært Dyb, er Tallet i Kartet understrøget.

Naar man bortser fra enkelte i Nærheden af Kysterne og paa grundt Vand optagne Vandprøver, varierer Saltgehalten paa de store Dyb mellem 3.59 og 3.45 %,

of the salt ocean-water of the Atlantic, distant but a few miles from land, its boundary being distinctly marked by the limits of the brackish water flowing along the shore. Except in this region, and a locality bordering the 70th parallel of latitude, where, for a short distance, it runs close to the coast, the boundary of the salt surface-water lies far out at sea.

This dilution of the surface-water on all parts of the Norwegian coast is not anywhere found to exert a material influence on the surface-temperature. The decrease in the amount of salt must be obviously ascribed to the influx of river-water, the temperature of which during the summer months is relatively high, — so high indeed, that the principal coastal current, flowing along the western shores of Norway, has a somewhat higher surface-temperature than that observed in its immediate vicinity. Phenomena the reverse of these prevail in the tract of ocean exposed to the influence of the Arctic, or East Greenland, current. There, the surface-water is not diluted by an influx of river-water, but with freshwater of a low temperature, produced by the melting of drift-ice; and hence a decrease in the percentage of salt is invariably attended with a corresponding reduction of the surface-temperature. The salt surface-water borders, therefore, not infrequently the Arctic current; and even where its boundary diverges from it, the transition from salt to comparatively fresh water is always accompained by a very considerable variation in temperature, proportionate to the variation in the amount of salt. That the surface-temperature becomes gradually lower on approaching the limits of the section in which the proportion of salt is 3.50 per cent, will be seen from the series of observations Nos. 115—120 and Nos. 207—209.

In the Arctic current, some distance from its extreme boundary, the proportion of salt at the surface was found to be very small, except in one locality, near the 75th parallel of latitude, where a narrow strip of salter water flows into the current, without, however, causing an appreciable rise in the surface-temperature. It is a remarkable fact, which must not be passed by unnoticed, that Professor G. O. Sars, naturalist to the Expedition, found here in the surface-water, which he examined from day to day, forms of animal life peculiar to the warm area of the Atlantic water, which he never met with in any other part of the cold East Greenland current.

As regards the amount of salt observed at great depths, the reader is referred to Pl. II, in which, as in Pl. I, will be found the percentage both at the bottom and at intermediate depths, provided the observations were taken with samples of water the temperature of which *in situ* was below 0°. Observations with water from intermediate depths are denoted by underlining the figures expressing their results.

Disregarding a few samples of water collected near the coast and in shallow spots, the proportion of salt, where the depth is great, ranges from 3.59 to 3.45 per

og Differentserne ere saaledes ogsaa her vel paaviselige om end mindre end i Overfladen. For tydeligt at kunne markere disse optrædende Differentser paa en let overskuelig Maade, har jeg benyttet forskjellige Farver. Saaledes ere de Strøg, hvor Saltgehalten beløber sig til 3.50 °/₀ eller derunder, betegnede med blaa Farve, de Strøg, hvor Saltgehalten ligger mellem 3.50 og 3.55 °/₀, med rød Farve, medens de Vandmasser, der ifølge Observationerne besidde en Saltmængde af over 3.55 °/₀, ere tegnede med en noget kraftigere rød Farve. I Nærheden af Kysterne er Kartet overalt ufarvet uden Hensyn til, om Vandet der henhører under den ene eller den anden af de tre Hovedgrupper.

Den uregelmæssige Fordeling af Saltgehalten i de større Dyb, som det saaledes tegnede Kart udviser, maa unegtelig betegnes som meget paafaldende. At Saltmængderne paa Bankerne og i den sydlige Del af Østhavet paa det Nærmeste findes at svare til den, som det i Overfladen svømmende varme Atlanterhavsvand besidder, kan ikke synes overraskende. Havet er her meget grundt, og det deri flydende Vand besidder overalt en Temperatur af over 0° og maa saaledes nærmest henføres til den nordover flydende Atlanterhavsstrøm, med hvilken det da ogsaa helt naturligt har Saltgehalt tilfælles. Ligeoverfor de store Dyb maatte man derimod paa Forhaand vente et andet Resultat. Temperaturen ligger her uden Undtagelse under 0° ja paa de fleste Steder endog under —1°, og det kunde derfor synes rimeligst at tilskrive det der flydende Vand polar Oprindelse. Det fremgaar imidlertid med Bestemthed af alle mig bekjendte Undersøgelser over Saltmængderne i de forskjellige Have, at de fra arktiske Egne udgaaende Strømme uden Undtagelse fører Vand af lavere Saltgehalt end de fra de mere tempererede Himmelstrøg udgaaende Varmvandsstrømme, og man skulde derfor i de dybere og koldere Lag af det her undersøgte Hav vente at finde en Vandmasse med adskilligt lavere Saltgehalt end den, der er funden i det i Overfladen og nærmest under den flydende Vand, som aabenbart skriver sig fra varmere Egne. Hvad der virkelig finder Sted er desuagtet dette, at det i de dybere liggende Lag flydende, iskolde Vand paa store Strækninger viser sig at have en Saltgehalt, der temmelig nøie svarer til den, der er funden i den atlantiske Overfladestrøm.

Saavel af denne Grund som ogsaa af andre Grunde, som jeg senere skal fremføre, finder jeg det rimeligt at gjøre den Antagelse, at Vandet paa de større Dyb paa de Steder, som i Kartet findes aflagte med rød Farve, enten udelukkende skriver sig fra varmere Egne eller under enhver Omstændighed er saa opblandet med saadant Vand, at det Hele derved antager en tydelig atlantisk Karakter, medens Vandet i de med blaa Farve betegnede Strækninger mere eller mindre skarpt udpræger sig som hidrørende fra polar Oprindelse.

Hvor det gjælder at besvare Spørgsmaalet om, hvorledes de øvre Lag finder Vei ned til Bunden, da synes dette ikke at kunne besvares paa anden Maade, end at det atlantiske Vand under stadig Afkjøling maa synke gjennem det iskolde og fordrive dette. Under enhver Omstæn-

cent; and there too, accordingly, the differences are appreciable, though smaller than at the surface. For the better apprehension of these differences, the sections in which they occur have been differently coloured in the Plate: blue indicates a percentage of 3.50, and under; red, a percentage ranging from 3.50 to 3.55; and a somewhat deeper red, a higher percentage than 3.55. Along the coasts, the Plate is left uncoloured, no matter to which of the three principal groups the water there belongs.

This irregular distribution of the amount of salt at great depths, as shown in the Plate, is certainly a most remarkable phenomenon. That the proportion of salt on the banks and in the southern portion of Barents' Sea should agree pretty closely with that contained in the warm surface-water of the Atlantic, is not indeed surprising: the depth is in both localities comparatively trifling, and the water, having everywhere a temperature above 0°, must be referred to the warm Atlantic current; its percentage of salt is therefore naturally the same as that of the Gulf Stream. For the great depths, on the other hand, there was reason to expect a very different result. Here, the temperature is without exception below 0°, nay in most places below —1°; and hence, as regards the origin of such water, there seems much to urge in favour of an indraught from the Polar Sea. Of the observations undertaken to determine the amount of salt in sea-water, all with which I am acquainted furnish incontestible proof that the water of the currents flowing from the Arctic Ocean has a lower percentage of salt than that of the warm currents flowing from more temperate regions; and the proportion of salt in the deeper and colder strata of the tract of ocean explored by the Expedition was expected, therefore, to prove considerably lower than that observed at the surface or a short distance beneath it, where the water is obviously an influx from warmer climes. But such was not the case, for the amount of salt found in the water of the cold area, where the temperature is below zero, agrees, in some localities, pretty closely with that in the water of the Atlanic surface-current.

This phenomenon, in conjunction with reasons that will afterwards be explained, has led me to assume, that the water met with at great depths in the sections coloured red in the Plate, is either exclusively the result of an influx from warmer regions, or is, at least, so mixed with such water as to have distinctly acquired Atlantic characteristics; whereas the water in the blue-coloured sections would seem to indicate more or less determinately a Polar origin.

As to the question involved in the descent of the upper strata to the bottom, the only way in which this can take place seems to be by the Atlantic surface-water, as it parts with its excess of heat, gradually sinking through the water of the cold area, and displacing it; at all events,

dighed synes det sikkert, at man for det afgrændsede østenfor Jan Mayen beliggende Strøg ikke kan antage nogen anden Vei. Men at den varmere Vandmasse saaledes skulde synke gjennem den koldere, kunde jo ved første Øiekast synes stridende mod vel kjendte Naturlove, da man nærmest maatte tro, at det i Nærheden af Overfladen flydende atlantiske Vand paa Grund af sin høiere Temperatur skulde være specifisk lettere end det ifølge sin lave Temperatur stærkt fortættede Bundvand. Nærmest for at fjerne enhver Tvivl i saa Henseende, er der i den forhen gjengivne Tabel opført en Rubrik for Vandprøvernes Egenvægter ved den i Havet observerede Temperatur i Forhold til rent Vand af 4°. Ved Hjælp af de der beregnede Tal kan man med Lethed studere den specifiske Vægts Variation med Dybden, saaledes som den finder Sted i Havet, bortseet fra den ved Vandets Sammentrykkelighed foraarsagede Fortætning i de større Dyb.

Den Region, som i denne Henseende mest interesserer os, er den, hvori der i Overfladen og nærmest under den findes en bestemt udpræget atlantisk Varmvandsstrøm, en Region, som paa det Nærmeste falder sammen med den søndenfor en Linie fra Island til Beeren Eiland liggende Del af Havet, dog saaledes at det nærmest Norge liggende Parti paa Grund af den fra Kysterne udgaaende Fortynding maa bortskjæres. Grupperer man de i denne Egn tagne Observationer over Saltgehalt og den specifiske Vægt reduceret til Havets Temperatur og en Atmosphæres Tryk efter Dybden, fremgaar som Resultat heraf Følgende.

Dybdeinterval.		Midlere Dybde.		Midlere Saltgehalt %	Midlere Egenvægt ved Havets Temperatur.
Engelske Favne.	Meter.	Engelske Favne.	Meter.		
0	0	0	0	3.526	1.02688
0—300	0—549	167	305	3.514	1.02782
300—600	549—1097	502	918	3.521	1.02812
600—1000	1097—1829	681	1245	3.513	1.02802
1000—1500	1829—2743	1203	2200	3.506	1.02800
under 1500	under 2743	1688	3087	3.507	1.02800

Det i denne Tabel erholdte Tal for Saltgehalten paa Strøget mellem 0 og 300 Favnes (0 og 549 Meters) Dyb er imidlertid uden Tvivl for lavt, da en uforholdsmæssig stor Del af Observationerne i dette Dyb hidrøre fra Østhavet, hvor Saltgehalten overalt er mindre end i de centrale og sydlige Dele af Feltet. De Observationer, som skrive sig fra dette Dyb i større Afstand fra Kysten, tyde hen paa, at Saltgehalten der meget nær svarer til den, der er funden i Overfladen paa de samme Steder. Denne Mislighed ved den geografiske Fordeling af Observationerne fra de mindre Dyb faar derimod ingen væsentlig Indflydelse paa det som Middel af de specifiske Vægter erholdte Tal, da den i de nordligere Egne ved Saltgehaltens Synkning foraarsagede Formindskelse af Egenvægterne paa det Nær-

it is certain that no other plausible explanation can be given of the phenomenon for the region east of Jan Mayen. But, that water of a higher temperature should sink in this manner through water of a lower, appears at first sight to be at variance with well-known physical laws; for the water from the Atlantic current having a higher temperature, one would imagine it to be specifically lighter than the cold and dense bottom-water. With the object of dispelling every doubt that might arise in connexion with this subject, a column has been added to the Table given above for the specific gravity of the samples of water at their temperature *in situ*, as compared with that of pure water of 4°. By means of the figures set down in the column, the variation of the specific gravity with the depth, as it occurs in the sea irrespective of increased density from the compressibility of water at great depths, may be readily investigated.

The tract of ocean which in this respect it will be most desirable to investigate, is that through which flows, on or near the surface, a warm current, setting from the Atlantic, — a tract which nearly coincides with the region stretching south of an imaginary line drawn from Iceland to Beeren Eiland, but from which, owing to the influx of freshwater, must be cut off the section extending along the Norwegian coast. Now, if we group together the observations taken in this part of the North-Atlantic to determine the percentage of salt and the specific gravity reduced to the temperature of the sea and a pressure of one atmosphere, the result will be as follows: —

Intervals of Depth.		Mean Depth.		Mean Amount of Salt per cent.	Mean Sp. Gr. at the Temp. of the Sea.
English Fathoms.	Metres.	English Fathoms.	Metres.		
0	0	0	0	3.526	1.02688
0—300	0—549	167	305	3.514	1.02782
300—600	549—1097	502	918	3.521	1.02812
600—1000	1097—1829	681	1245	3.513	1.02802
1000—1500	1829—2743	1203	2200	3.506	1.02800
below 1500	below 2743	1688	3087	3.507	1.02800

The figures in this Table expressing the amount of salt at depths ranging from 0 to 300 fathoms (0—549 metres) are, however, unquestionably too low, seeing that a disproportionate number of the observations at this depth were taken in Barents' Sea, where the amount of salt is everywhere smaller than in the central and southern sections of the tract investigated. The observations referring to this depth at a considerable distance from land, show that the percentage of salt is very nearly the same as that at the surface. The said defect in the geographical distribution of the observations taken at a comparatively trifling depth, does not however materially affect the correctness of the figures expressing the mean specific gravity; for the fall in specific gravity occasioned in northern regions

meste opveies af den Forøgelse af samme, der skyldes de der herskende lavere Temperaturer.

Det fremgaar altsaa, at Differentserne mellem Saltgehalten i de atlantiske Overfladelag og de paa Bunden hvilende iskolde Vandmasser gjennemsnitlig kun ere meget smaa, om de end paa de Puncter, hvor Vandet i de dybere Lag besidder en overveiende polar Karakter, turde være adskilligt mere fremtrædende. Disse Differentser af henimod 0.02 % ere dog mere end tilstrækkelig store til i de nederste mere afkjølede Lag af det atlantiske Vand at fremkalde et, som det vil sees af Tabellen, meget tydeligt om end svagt Maximum af den specifiske Vægt, hvad der nærmest bevirkes derved, at Søvandet ved Afkjøling under 0° nærmer sig sit Tæthedsmaximum og derfor i Nærheden af dette for mindre Temperaturvariationer kun forandrer sit Volum med næsten umærkelig smaa Værdier, saaledes at en selv meget ringe Forøgelse af Saltgehalten under disse Omstændigheder faar en overveiende Indflydelse ligeoverfor en Grads Forandring af Temperaturen.

Det er saaledes saa langt fra Tilfælde, at der i de specifiske Vægter af de forskjellige Vandlag ligger nogen Hindring for Antagelsen af, at det atlantiske Vand skulde synke gjennem det koldere Polarvand, at man tvertom af disse maa slutte, at saa maa være Tilfælde, dersom ikke andre i Havet herskende Strømme virke hemmende paa en saadan Bevægelse. Man tænke sig f. Ex. ved Siden af hinanden i Havet to Vandsøiler af 2000 Favnes (3658 Meters) Dybde, hvori Temperaturens Variation med Dybden for Simpelheds Skyld kan antages at være den samme, hvorimod Saltgehalten i den 1ste helt igjennem sættes til 3.52 %, medens den i den 2den paa Strøget fra Overfladen til 500 Favnes (914 Meters) Dyb gives Værdien 3.52 % og fra 500 til 2000 (914 til 3658) Værdien 3.50 %, saaledes som Forholdet ifølge Observationerne virkelig synes at stille sig paa enkelte Steder i det undersøgte Hav. Det er da umiddelbart indlysende, at en saadan Fordeling af Saltgehalten vil have en Synkning i den 1ste Søile til Følge, saaledes at Vandet i denne vil søge at udbrede sig langs Bunden og fordrive det omliggende specifisk lettere Vand. Den Hastighed, hvormed en saadan Bevægelse foregaar, vil naturligvis rette sig efter Differentsen mellem Trykkene i samme Niveau i begge Søiler, en Differents, som ved Bunden i 2000 Favnes (3658 Meters) Dyb efter Beregning beløber sig til henimod 32^{mm} Kviksølvsøile.

For nærmere at begrunde den forhen fremsatte Hypothese, om at det paa Bunden hvilende iskolde Vand paa de i Kartet med rød Farve betegnede Steder skulde have atlantisk Oprindelse, vil jeg benytte mig af de i en tidligere Afhandling[1] beskrevne Observationer over de i Søvandet indeholdte Kvælstofmængder, hvis Anvendelse i saadant Øiemed allerede paa det Sted løselig er bleven antydet.

Som bekjendt herskede der i ældre Tider den Anskuelse, at de i Søvandet i de større Dyb indeholdte Luftmængder paa Grund af det der herskende Tryk maatte

[1] "Om Luften i Søvandet."

by a decrease in the amount of salt, is almost compensated by the rise resulting from the low temperatures prevailing there.

It appears, therefore, that the differences between the amount of salt in the warm upper strata and that in the cold water at the bottom, are, on an average, exceedingly small, though more striking perhaps in localities where the water of the deeper strata to a very great extent is Polar in origin. These differences — about 0.02 per cent — are, however, as will be seen from the Table, more than sufficient in the deepest and coldest strata of Atlantic water to occasion an appreciable, though a low, maximum of specific gravity, which is explained by the fact, that sea-water below 0° has very nearly reached its maximum of density, and the increase in volume then resulting from trifling variations in temperature, is a well nigh inappreciable magnitude: hence, under such circumstances, the influence of a very slight addition to the amount of salt with but one degree's difference in temperature will be exceedingly great.

Such being the case, there is nothing in the specific gravities observed in the different strata of water to disfavour the assumption that the comparatively warm Atlantic water should sink through the cold water of Polar origin; nay, from these specific gravities we may infer its correctness, provided only that such descending motion be not counteracted by the effect of ocean currents. To give an illustration. Let us imagine two columns of water, 2000 fathoms (3658 metres) deep, in both of which, for convenience' sake, the variation in temperature with the depth is assumed to be equal; the amount of salt on the other hand, being put at 3.52 per cent throughout the whole of the first, but in the second, at 3.52 per cent from the surface to a depth of 500 fathoms (914 metres), at 3.50 per cent from 500 to 2000 fathoms (914—3658 metres), — a ratio of distribution actually observed in some localities. This given, it is obvious that such a distribution must cause the water in the first column to sink, and spread itself over the bottom, displacing as it does so the specifically lighter. The rapidity of this downward motion will of course be proportionate with the difference in pressure at the same level in the two columns, a difference which, at the depth of 2000 fathoms (3658 metres), has been computed equal to that of a column of mercury 32^{mm} in height.

With a view to furnish additional confirmation of the hypothesis brought forward above, which assumes the cold bottom-water in the red-coloured sections of the Plate to be of Atlantic origin, I shall have recourse to my observations on the amount of nitrogen in sea-water, published in a former paper,[1] where their application to such a purpose was briefly alluded to.

The opinion formerly entertained, that the quantity of air contained in sea-water at great depths must be exceedingly great, by reason of the immense pressure pre-

[1] "On the Air in Sea-Water."

være uforholdsmæssig store, en Anskuelse, som ved de senere Undersøgelser fuldstændig er bleven modbevist. Rigtignok er det paa den engelske Challengerexpedition iagttaget, at de i den hede Zone fra Havbunden optagne Vandprøver ved at henstaa nogen Tid vise Overmætningsphænomener, men dette vil jo ikke være vanskeligt at forklare, naar man erindrer, at Vandet i de store Dyb selv i Æqvatoregnene er meget nær iskoldt. Det følger nemlig af sig selv, at de til en saa lav Temperatur svarende Luftmængder ikke kunne holdes opløste, naar Vandprøverne ved længere Tids Henstand antager de tropiske Egnes høie Lufttemperatur. Stærkest taler de paa den norske Expedition udførte Luftbestemmelser for, at Tryktilvæxten med Dybden ikke kan have nogen Indflydelse paa Mængden af den i Søvandet opløste Luft. Tager man nemlig Middelet af Dybder, Temperaturer og Kvælstofmængder for alle de fra Puncter under Overfladen stammende Vandprøver, hvori der paa denne Expedition er foretaget Luftbestemmelser, erholder man til et Middeldyb 693 Favne (1267 Meter) en Middeltemperatur — 0.°05 og en midlere Kvælstofgehalt 13.99 CC. per Litre, det vil sige, Vandet i Dybet indeholder gjennemsnitlig næsten 0.5 CC. Kvælstof *mindre*, end det ved sin Temperatur vilde kunne holde opløst under en Atmosphæres Tryk.

Naar man erindrer, at Trykket i Havdybene ikke dreier sig om Atmosphærer men om Hundreder af Atmosphærer, saa maatte man dog vente, at dets Indflydelse (om det havde nogen) vilde give sig tilkjende ved Uregelmæssigheder af paaviselig Størrelse, og man er, da dette ikke i mindste Maade er Tilfældet, berettiget til den Slutning, at Trykket ikke besidder nogen Evne til i mærkbar Grad at ophobe Luftmængderne i de store Dyb. Paa den anden Side maa det fornuftigvis antages, at Vandet i de dybere liggende Lag ikke kan afgive noget af sin Luft, da det jo paa Grund af det der herskende Tryk vil kunne holde opløst overveiende større Mængder end de, der nogensinde ere forefundne.

Den rimeligste Slutning af de senere Tiders Observationer over disse Gjenstande vil saaledes være den, at en Vandprøve, saalænge den befinder sig under Overfladen, uforandret vil beholde den samme Luftmængde eller rigtigere Kvælstofmængde[1], som den havde absorberet, da den sidste Gang befandt sig i Overfladen udsat for Luftens frie Indvirkning.

Nu er den Luftmængde, som Søvandet absorberer af Atmosphæren, hovedsagelig afhængig af Vandets Temperatur, idet Barometerstandens Variationer ligeoverfor større Temperaturdifferentser kun har en underordnet Betydning. Heraf følger, at de Vandmasser, der have absorberet sin Luftmængde under varmere Himmelstrøg, maa være forholdsvis

[1] Den absorberede Surstofmængde er nemlig i nogen Grad afhængig af Dyrelivet og andre Tilfældigheder, saaledes at det her ligesom i den tidligere Afhandling vil være det Rigtigste at anvende Kvælstofmængden som Maal for den samlede Luftmængde.

vailing there, has been wholly refuted by the results of later observations. True, the samples of water obtained at great depths within the tropics on the 'Challenger' Expedition were found to exhibit the phenomena of supersaturation when allowed to stand over some time; this, however, is easily explained, if we call to mind that the water at great depths, even in equatorial regions, has a temperature but little above zero. Hence it naturally follows, that the quantity of air corresponding to so low a temperature cannot be retained on the samples of water having stood over sufficiently long to acquire the high temperature of the atmosphere in tropical climates. The air-determinations performed on the Norwegian Expedition afford the strongest proof of the fact, that the increase of pressure with the depth does not exert any appreciable influence on the proportion of air in sea-water. Now, if we compute the mean depth, temperature, and amount of nitrogen for all the samples of water from below the surface examined for air-determinations, the result will be as follows: mean depth 693 fathoms (1,267 metres); mean temperature — 0.°05; mean amount of nitrogen 13.99^{cc} per litre, which shows that in the depths of the ocean the proportion of nitrogen averages 0.5^{cc} *less* than could be absorbed by sea-water of the temperature prevailing there with the pressure of one atmosphere.

If we call to mind that the pressure in the depths of the sea is not computed even by tens, but by hundreds of atmospheres, its influence, if any, must surely, one would imagine, occasion irregularities of appreciable magnitude; and we may therefore safely conclude, since no such disturbance can be detected, that pressure does not perceptibly increase the amount of air at great depths. On the other hand, there is every reason to infer, that the water in the lower strata, owing to the immense pressure, cannot part with any of its air, the quantity actually absorbed never being even approximately so great as such a pressure would enable it to retain.

From the latest observations throwing light on this question, we may therefore reasonably infer, that all sea-water below the surface retains undiminished the quantity of air, or rather of nitrogen,[1] which it absorbed when last at the surface, in direct contact with the atmosphere.

Now, the quantity of air absorbed by sea-water is mainly dependent on the temperature of the latter, the rise or fall of the barometer, as compared with considerable differences in temperature, being in this case of but little moment. Hence it follows, that the proportion of air absorbed by sea-water in warm climates is small compared

[1] The amount of oxygen absorbed by sea-water depending to a certain extent on the presence of animal life and other accidental causes, the amount of nitrogen may, with greater precision, be assumed to represent the total amount of air — a standard of measurement adopted in the preceeding Memoir.

lidet luftholdige, medens de, der have absorberet sin Luftmængde i de arktiske Egne, maa indeholde meget større Mængder, og man vil derfor netop i de paa Expeditionen udførte Gasanalyser have et fortrinligt Middel til at controllere den forhen opstillede Hypothese, ifølge hvilken enkelte Regioner af det iskolde Dyb skulde være opfyldt af Vandmasser, der ialfald delvis havde atlantisk Oprindelse.

Forat vise Udfaldet af en saadan Control har jeg tegnet Kartet No. III, hvorpaa efter samme Princip som det ved Tegning af Kartet No. II befulgte findes afsat de i Dybet fundne Kvælstofmængder udtrykte i CC. pr. Litre reducerede til 0° og 760^{mm} Tryk, ligesom der ogsaa ved Siden af disse Tal findes opført den Temperatur, hvorved Søvandet absorberer denne Kvælstofmængde, beregnet til nærmeste hel Grad efter den af de tidligere bskrevne Forsøg udledede Formel

$$N = 14.4 - 0.23t.$$

Det siger sig selv, at disse Temperaturer ikke kunne gjøre Fordring paa nogen stor Grad af Nøiagtighed. da en forholdsvis liden Feil i Kvælstofbestemmelsen bevirker en meget stor Feil i den deraf beregnede Temperatur. Der findes saaledes flere Observationer, der give Temperaturen — 4°, en Temperatur, der mig bekjendt ikke er observeret i Havet. Dette vil dog ikke forekomme saa urimeligt, naar man tager Hensyn til, at Søvand af —2° ved 780^{mm} Barometerstand absorberer en Kvælstofmængde, der paa det Nærmeste gaar op til, hvad der i Ydertilfældene er fundet.

Farvelægningen er her foretagen saaledes, at de Strøg, hvor Kvælstofmængden er funden at være 14.4 CC. eller derover, ere betegnede med blaa Farve, de Strøg, hvor Kvælstofmængden ligger mellem 14.4 og 12.5 CC., med en svag rød Farve, medens et mindre Parti, hvor Kvælstofmængden er funden at ligge under 12.5 CC., er betegnet med en noget kraftigere rød Farve. Betydningen af disse Farver bliver ligesom i Kartet No. II den, at de røde Farver bedække de Strækninger, hvor Vandet i mere eller mindre Grad besidder atlantisk Karakter, medens den blaa Farve tilhører de Vandmasser, der have absorberet sin Kvælstofmængde ved en Temperatur af under 0°, og som altsaa nærmest synes at hidrøre fra de arktiske Egne.

Ved at sammenligne Kartene No. II og III vil man strax se, at Farvelægningen i disse i alt Væsentligt viser en særdeles stor Overensstemmelse, som paa mange Puncter endog nærmer sig til Congruents, om man end ved nærmere Betragtning vil finde, at disse Ligheder ikke gaa igjen i alle Detailler, hvad man heller ikke paa nogen Maade kunde vente. Grændserne bliver nemlig paa Kartet No. III paa Grund af Observationernes Faatallighed meget vanskelige at bestemme, ja der findes endog her paa omkring den 65de Breddegrad et større Strøg, hvorom man intet med Bestemthed kan slutte, da der under Analysen tabtes en mindre Del af de Luftprøver, der vare bestemte til at udfylde dette Hul, saaledes at den samlede Luftmængde desværre ikke kunde maales. Desuden ere ogsaa Observationsfeilene baade for Salt- og Kvælstofbestemmel-

with that absorbed in the Arctic regions, wherefore the analyses of gas performed on the Expedition furnish an excellent means of testing the value of the hypothesis according to which certain sections of the cold area are assumed to be made up of water part of which at least would seem to be of Atlantic origin.

To show the result of such a test, I have annexed a third Plate (drawn on the same principle as Pl. II), in which are given the different amounts of nitrogen present in deep water, expressed in c.centim. per litre, reduced to 0° and a pressure of 760^{mm}. Along with these figures will be found, too, the temperature at which sea-water absorbs such an amount of nitrogen, computed, in whole degrees, by means of the formula deduced from the observations previously described, viz: —

$$N = 14.4 - 0.23t.$$

These temperatures cannot of course pretend to any high degree of accuracy, a comparatively small error in a nitrogen-determination involving a very considerable error in the temperature. Thus, for instance, several of the observations indicate — 4°, a temperature which, so far as I am aware, was not anywhere observed in the sea. This, however, will not appear so strange, if regard be had to the fact, that sea-water of — 2°, at a pressure corresponding to 780^{mm}, absorbs an amount of nitrogen which agrees very closely with the highest found on the Expedition.

The sections in this Plate are coloured as follows: those in which the amount of nitrogen was found to equal or to exceed 14.4^{cc}, blue; those in which it ranged from 14.4 to 12.5^{cc}, light red; a somewhat deeper red serves to indicate a small tract in which the amount of nitrogen did not reach 12.5. Moreover, as in Plate II, the red colour indicates water more or less distinguished by Atlantic characteristics; the blue, water in which the nitrogen was absorbed at a temperature below 0°, and which, therefore, would seem to have derived its origin from some part of the Polar Seas.

A comparison of Plates II and III will at once show considerable agreement in the distribution of colour, many of the sections almost coinciding; though, on closer inspection this approach to congruity is not found to characterise all details, which indeed there was no reason to expect. In Pl. III, the limits proved exceedingly difficult to define, owing to the limited number of observations; nay, respecting an extensive tract near the 65th parallel of latitude nothing definite can be inferred, part of several samples of air, the analysis of which would have served to fill up the blank, having been unfortunately lost, and the total amount of air could not, therefore, be measured. Besides, the errors of observation both in the salt and the nitrogen determinations, are so considerable, when compared with the minute differences in amount, that, in some

sernes Vedkommende af saadan Størrelse, at de i Sammenligning med de smaa Differentser, som det her gjælder at paavise, lettelig paa sine Steder kunne gjøre sig gjældende og frembringe Uoverensstemmelser, hvor de i Tilfælde af absolut nøiagtige Observationer ikke vilde findes.

Hvilken Vægt man nu end vil tillægge disse faa Forskjelligheder mellem de to Karter, saa meget er dog sikkert, at de kun optræde som Undtagelser, medens den langt stærkere fremtrædende Regel er Overensstemmelser af saadan Art, at de ikke uden videre kunne tilskrives Tilfældigheder. Der existerer uimodsigeligt en paa mange Puncter næsten til Proportionalitet grændsende lovmæssig Forbindelse mellem Saltgehalten og Kvælstofmængderne, som muligens ikke turde lade sig forklare paa anden Maade end netop gjennem den før omtalte Hypothese, som saaledes maa ansees for at indeholde ialfald en stor Del Sandhed, idet den samtidig bestyrkes af to af hinanden fuldstændig uafhængige, uensartede Observationsrækker, der i alt Væsentligt give det samme Resultat.

Den, som det synes, største Vanskelighed ved denne Hypothese bestaar i at forklare, hvorledes det i de store Dyb flydende atlantiske Vand skulde have antaget en saa lav Temperatur, som det ifølge Observationerne viser sig at besidde. Dette turde dog maaske ikke synes saa urimeligt, naar man betænker, at den varme, søndenfra kommende Atlanterhavsstrøm ved at flyde henover det underliggende meget kolde Vand paa de nærmest til dette grændsende Lag maa blive udsat for en meget stærk Afkjøling nedenfra, og at det først gjennem en saadan Afkjøling til omkring 0° opnaar den høie specifiske Vægt, der er den nødvendige Betingelse for, at det skal kunne synke tilbunds. Det atlantiske Vand har altsaa, allerede førend det begynder at synke, antaget en meget lav Temperatur og vil desforuden under selve Synkningen, idet det da kanske i et meget langt Tidsrum befinder sig paa alle Sider omgivet af polart Vand, end yderligere blive Gjenstand for Afkjøling, førend det naar Bunden. Det fremgaar forøvrigt ogsaa af de endnu ikke offentliggjorte Temperaturobservationer, som jeg desuagtet ved Velvillie af Professor Mohn har faaet Anledning til at gjøre mig bekjendt med, at Temperaturen i de store Dyb paa de med rød Farve betegnede Partier er noget høiere end der, hvor Kartet er farvet blaat, saaledes at i Virkeligheden ogsaa Temperaturforholdene tale for den opstillede Hypothese.

Det vilde dog være paa urette Sted paa dette Stadium at forsøge udredet alle Vanskeligheder, saalænge de paa Expeditionen udførte talrige Temperaturbestemmelser endnu ikke ere forelagte Offentligheden, da man alene ved at tage tilbørligt Hensyn til det hele foreliggende Materiale af Observationer vil kunne vente at faa det bedst mulige Indblik i de mere indviklede Spørgsmaal om Strømforholdene. Det er dog meget sandsynligt, at man senerehen ved at combinere alle Data vil kunne kaste Lys over meget, som nu maa synes dunkelt.

Uheldigvis var det ved Expeditionens Udreise ikke muligt at forudse, at de chemiske Observationer skulde kunne føre til Slutninger af saadan Art som de her paa-

of the computations, they might easily affect the result, and give rise to discrepancies which, with perfectly accurate observations, there would be no fear of.

Whatever weight may be attached to these differences, they must unquestionably be regarded as exceptional; the rule is agreement, and of a character precluding the possibility of ascribing it to chance. Many of the observations prove incontestibly the existence of a definite, well nigh proportional connexion between the amount of salt and that of nitrogen, a connexion difficult, perhaps, to explain without having recourse to the aforesaid hypothesis, which cannot but come near the truth, confirmed as it is by two widely different series of observations, leading, each independently of the other, in all essential points, to the same result.

The greatest apparent difficulty involved in this hypothesis consists in explaining the low temperature of the Atlantic water in the deeper strata. We must, however, bear in mind that the warm Atlantic current, in flowing over the cold water of the lower strata, is necessarily made to part with a very considerable amount of heat; and that the high specific gravity, without which it could not sink to the bottom, involves a temperature of about 0°. Hence, the Atlantic water will have acquired a very low temperature before beginning to sink, and moreover, being surrounded during its downward passage, possibly for a considerable period, by Polar water, give off a further amount of heat ere it reaches the bottom. For the rest, it appears from the independent series of temperature observations, not yet in print, with which Professor Mohn has kindly made me acquainted, that the temperature at great depths in the sections coloured red in the Plate, is somewhat higher than in those coloured blue; and hence the hypothesis adopted here derives additional support from the variation in temperature.

Meanwhile, it would be premature to attempt disposing of all difficulties, till the numerous temperature determinations performed on the Expedition shall have been made public, since to elucidate fully the more intricate questions connected with ocean currents, the whole stock of materials must be dealt with. We may however venture to hope, that, at a later stage of this interesting inquiry, a general combination of data will throw light upon much that is at present involved in obscurity.

Unfortunately, it was not possible to foresee on the departure of the Expedition, that such inferences as those here pointed out would be drawn from the chemical ob

pegede, og det er derfor helt naturligt, naar Undersøgelserne ikke i Henseende til Studiet af tidligere ukjendte Eiendommeligheder ved Havet kunde føre til saa fyldige Resultater, som ønskeligt kunde være. Men om end disse Undersøgelser paa Grund heraf nærmest faa Karakteren af forberedende Arbeider, saa vil det dog, som jeg haaber, indrømmes, at de desuagtet kunne have sine maaske ikke uvigtige Følger, idet de vise, at man gjennem de chemiske Observationer, der tidligere i Sammenligning med Temperatur- og Dybdebestemmelser har spillet en mindre fremtrædende Rolle ved Studiet af Havets Physik, vil kunne skaffe Oplysninger om mærkelige Forholde i Havet, som man ad anden Vei vanskelig skulde falde paa at søge opklarede. Man vil ved Hjælp af de her erholdte Resultater med Lethed i Fremtiden kunne udkaste en detailleret Plan for en fornyet Undersøgelse af det norske Hav, der i mine Øine stiller sig som særdeles ønskelig, da man ved at gjøre et hidindtil ukjendt Hav til Gjenstand for Bearbeidelse vanskelig turde gjøre Regning paa at træffe et, der i Henseende til Studiet af Strømforholdene er saa instructivt som det norske Hav.

Ved saadanne fremtidige Undersøgelser kunne de paa den norske Expedition benyttede Arbeidsmethoder ikke i alle Retninger blive optagne i uforandret Form, og det vil derfor ikke være ubeføiet til Slutning med faa Ord at paapege de Mangler, der klæbe ved disse.

De til Saltbestemmelserne tidligere benyttede Methoder, ifølge hvilke alle herhen hørende Observationer anstilles ombord, bør utvivlsomt for Fremtiden ikke komme til Anvendelse, da man ad den Vei tiltrods for al anvendt Møie ikke vil kunne opnaa den Nøiagtighed, som tiltrænges for med ønskelig Sikkerhed at kunne paavise de i Havet forekommende ofte meget smaa Differentser. Paa den norske Expedition blev denne Fremgangsmaade benyttet, fordi man med ældre Iagttageres Udtalelser for Øie maatte befrygte, at Søvand ikke lod sig opbevare i længere Tidsrum uden at undergaa forskjellige Forandringer, en Frygt, der imidlertid efter min Erfaring kun forsaavidt er begrundet, som man til Opbevaring af Vandet benytter Kar, der ere forsynede med Korkeprop. Jeg har nemlig undersøgt flere Vandprøver, der have været opbevarede paa denne Maade i omkring 2 Aar og fundet, at de alle uden Undtagelse have undergaaet Forandringer af saadan Art, at man turde være berettiget til at anse dem uskikkede til Egenvægtsbestemmelse, hvorimod jeg hos Vandprøver, der i lignende Tidsrum havde henstaaet paa Flasker forsynede med isleben Glasprop, ikke kunde opdage nogensomhelst Eiendommeligheder, der kunde adskille dem fra friskt øste Vandprøver. Ved denne Opbevaringsmaade risikerer man dog ganske sikkert Fordunstning af en Del af Vandet, og man maa derfor beskytte sig mod denne Feilkilde ved at hjemføre det til Saltbestemmelser bestemte Vand paa tilsmeltede Glasrør.

I de saaledes conserverede Vandprøver vil man senerehen efter Hjemkomsten kunne bestemme Egenvægten ved Sprengels Pyknometer og Chlorgehalten ved Hjælp af Veiningsanalyser med saadan Skarphed, som man ved Arbeide

servations, and hence the results of the work done, embracing as it did the investigation of phenomena unknown before, were naturally less comprehensive than might otherwise have been attained. But, though such labours must to a certain extent, be regarded as preliminary, they will, I trust, prove of considerable importance, showing as they do, that chemical observations, which, as compared with determinations of temperature and depth, previously held quite a subordinate rank among the means employed for studying the physical conditions of the ocean, will serve to throw light upon many remarkable phenomena, that without such data would be extremely difficult to explain. On the basis of the results here set forth, a detailed plan might be easily laid down for the further exploration of the Norwegian Sea, — in my opinion a most desirable undertaking, since of ocean tracts as yet unknown, there are probably few that, in regard to the study of ocean currents, would so well repay investigation as that section of the North-Atlantic.

As several of the methods of investigation practised on the Norwegian Expedition, will not admit of being adopted on future occasions in a wholly unmodified form, it will not be out of place in conclusion briefly to point out their defects.

The methods previously devised for determining the amount of salt in sea-water, by which all observations with this object in view were taken on board, should unquestionably cease to be adopted, since they will not suffice, with the greasest care even, to attain the high degree of accuracy requisite for detecting such minute differences as are frequently found to occur. These defective modes of operation were, however, adopted on the Norwegian Expedition, there being reason to believe from the statements of earlier observers, that sea-water could not be preserved for any length of time without undergoing chemical change, a supposition which, so far as my experience goes, is confirmed only in the event of its being kept in *corked* vessels. I have examined, for instance, various samples of sea-water that had been preserved for about 2 years in corked bottles, and found all without exception to have undergone a change sufficient to render them unfit for specific gravity determinations; whereas, on the other hand, sea-water which had been allowed to stand over for the same space of time in bottles furnished with ground glass stoppers, was not to be distinguished from freshly drawn samples. There is, however, a risk of loss from evaporation, the stoppers being seldom, if ever, tight-fitting; and to guard against this source of error, the water for salt-determinations must be brought home in hermetically sealed glass tubes.

With water thus preserved, the specific gravity may be determined by means of Sprengel's pycnometer, and the amount of chlorine by weighing, on the return of the Expedition, far more accurately than would be possible on

ombord ikke i fjerneste Maade vil kunne gjøre Regning paa at opnaa, hvorhos man tillige vil have den Fordel at kunne benytte directe Saltbestemmelser som Controlmiddel.

Mod de paa Expeditionen udførte Luftbestemmelser vil ikke kunne gjøres nogen væsentlig Indvending, med mindre man skulde anke over, at de benyttede Vandprøver ere optagne ved Hjælp af Apparater, der ikke vare omgivne med slette Varmeledere, saaledes at de ved Ankomsten til Overfladen vilde have havt Anledning til at antage en i Forhold til sin Luftmængde noget for høi Temperatur. Denne Feilkilde kan dog ikke antages at have faaet nogen væsentlig Indflydelse i et Hav som det her undersøgte, hvor kun et meget tyndt Lag nærmest Overfladen besidder en Temperatur af over 5°, især da Vand, der kun er svagt overmættet med Luft, meget langsomt giver Slip paa den overskydende Del.

Det ved Udkogningen benyttede, af Jacobsen beskrevne Apparat er i alt Væsentligt fundet særdeles bekvemt, kun vilde det maaske være hensigtsmæssigt at give Luftopsamlingsrøret en noget forandret Form, hvorved man lettelig vilde undgaa den Vanskelighed, hvormed det nu er forbundet at overfylde Luftmængden i Eudiometret uden Tab.

board; moreover, there is the additional advantage of being able to test the results by direct salt-determinations.

As regards the air-determinations performed on the Expedition, their general accuracy can hardly be impugned. True, the apparatus with which the samples of water were collected not having been surrounded by a non-conducting medium, they may possibly in their passage to the surface have assumed a temperature somewhat too high as compared with the amount of air contained in them; but the error arising from this source cannot have exerted any material influence, since the tract of ocean investigated has but a thin stratum of water in which the temperature rises above 5°; besides, water slightly surcharged with air is found to part very slowly with the surplus portion.

The boiling-apparatus devised by Jacobsen proved very convenient; possibly, however, the tube for collecting air might be given a somewhat different form, to obviate the difficulty now experienced in transferring the air to the eudiometer without loss.

Ovenstaaende Afhandlinger ere indsendte til Redactionscomiteen for den norske Nordhavsexpeditions Generalberetning, No. I og II i April 1879 og No. III i December samme Aar.

De i disse 3 Afhandlinger beskrevne Observationer ere, forsaavidt de ikke ere udførte ombord, anstillede i Professor Waages Afdeling af Universitetets chemiske Laboratorium i Christiania.

Sluttelig benytter jeg Anledningen til at udtale min Tak til D'Hrr Professorerne Waage og Mohn for den Bistand, de under mit Arbeide med disse Gjenstande paa flere Puncter har ydet mig.

These Memoirs were sent in to the Editorial Committee for the Norwegian North-Atlantic Expedition as follows: — Nos. I and II in April 1879 and No. III in December.

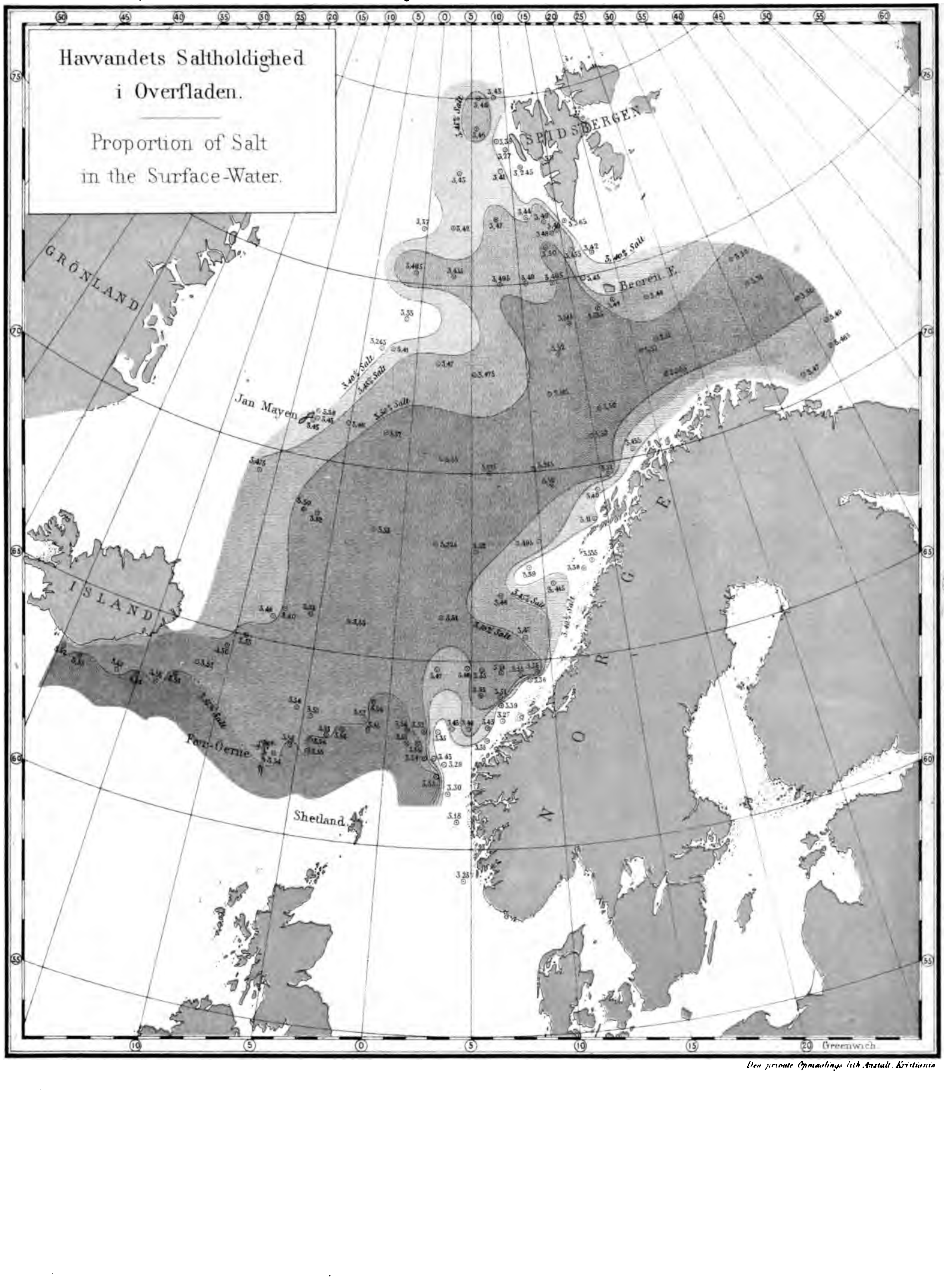
The observations set forth in the foregoing Memoirs were, when not taken on board, instituted in Professor Waage's department of the Chemical Laboratory of the University of Christiania.

In conclusion, I must not omit to thank Professors Waage and Mohn for the assistance they kindly rendered me, in certain respects, when engaged on the investigation of the subjects treated of in these papers.

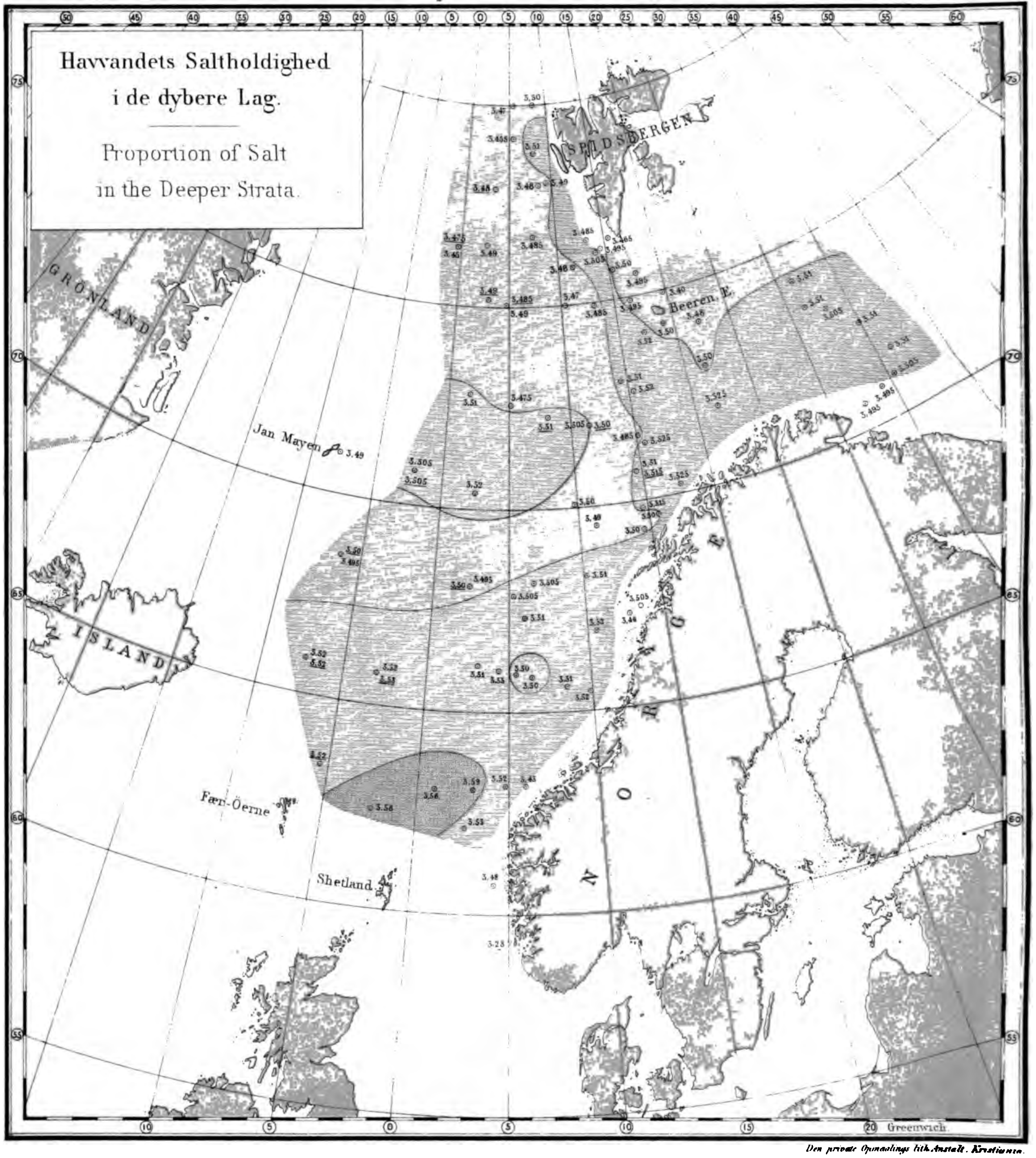
Errata.

Page 3, line 26, from top of page, *for* '35.4 to 32.4 — 33.6 per cent, being' *read* '35.4 to 32.4, 33.6 per cent being.'
— 9, line 20, from top of page, *for* 'the extent to which the results based on that hypothesis,' etc. *read* 'the slight extent to which Jacobsen's results,' etc.
— 28, line 22, from top of page, *for* 'soda was added, and the whole compound' *read* 'carbonate of soda was added, and the whole mixture.'
— 38, line 3, from foot of page, *for* 'soda' *read* 'carbonate of soda.'
— 39, line 13, from foot of page, *for* 'soda' *read* 'carbonate of soda.'

Translated into English by John Hazeland.



Den private Opmaalings lith. Anstalt. Kristiania



Den private Opmaalings lith. Anstalt. Kristiania.

THE NORWEGIAN NORTH-ATLANTIC EXPEDITION

1876—1878.

CHEMISTRY.

I. ON THE AIR IN SEA-WATER.
II. ON THE CARBONIC ACID IN SEA-WATER.
III. ON THE AMOUNT OF SALT IN THE WATER OF THE NORWEGIAN SEA.

BY

HERCULES TORNØE.

WITH 3 WOODCUTS AND 3 MAPS.

CHRISTIANIA.
PRINTED BY GRØNDAHL & SØN.
1880.

BODL. LIBR.

DEN NORSKE NORDHAVS-EXPEDITION 1876—1878.

IX.

CHEMI.

I. OM SØVANDETS FASTE BESTANDDELE.
II. OM HAVBUNDENS AFLEIRINGER.

AF

LUDVIG SCHMELCK.

MED 1 TRÆSNIT OG 2 KARTER.

CHRISTIANIA.
GRØNDAHL & SØNS BOGTRYKKERI.
1882.

I COMMISSION HOS H. ASCHEHOUG & Co.

DEN NORSKE NORDHAVS-EXPEDITION

1876—1878.

General reports

CHEMI.

I. OM SØVANDETS FASTE BESTANDDELE.

II. OM HAVBUNDENS AFLEIRINGER.

AF

LUDVIG SCHMELCK.

MED 1 TRÆSNIT OG 2 KARTER.

CHRISTIANIA.
GRØNDAHL & SØNS BOGTRYKKERI.
1882.

THE NORWEGIAN NORTH-ATLANTIC EXPEDITION

1876—1878.

CHEMISTRY.

I. ON THE SOLID MATTER IN SEA-WATER.

II. ON OCEANIC DEPOSITS.

BY

LUDVIG SCHMELCK.

WITH 1 WOODCUT AND 2 MAPS.

CHRISTIANIA.
PRINTED BY GRØNDAHL & SØN.
1882.

Om Søvandets faste Bestanddele.

Den temmelig rige Literatur, der handler om Søvandsundersøgelser, gaar helt tilbage til Slutningen af det forrige Aarhundrede. De Kemikere, der fra Begyndelsen af tog dette Emne under Behandling, lagde naturligvis først og fremst Vægten paa at bestemme Vandets samlede Saltmængde eller dets tilsvarende Egenvægt i de forskjellige Dele af Oceanet.

De første Undersøgelser i denne Retning førte snart til den Slutning, at Havets Saltholdighed ikke var underkastet andre Forandringer, som ved Datidens analytiske Midler kunde paavises, end slige, der var en nødvendig Følge af særegne forud bekjendte Naturforhold, f. Ex. Fortyndningen i de polare Egne ved store Ismassers Smeltning. Denne Havets Ensartethed med Hensyn til dets samlede Saltgehalt sandsynliggjorde naturligvis ogsaa den Antagelse, at Forholdet mellem dets enkelte Bestanddele var af en lignende uforanderlig Beskaffenhed. Skjønt de første Forsøg paa at bestemme Søsaltets Sammensætning ikke førte til saadanne Resultater, der fra Kemiens nuværende Standpunkt vilde betegnes som overensstemmende, ser vi dog, at allerede Marcet (Phil. trans. 1822) drager den Slutning af sine Søvandsundersøgelser, at der kun er meget liden Variation i Forholdet mellem Kalk, Magnesia, Klor og Svovlsyre i Havvandet. At Havet er en ensartet Blanding, eller at Variationerne i dets Sammensætning kun kan dreie sig om smaa Størrelser, er senere bekræftet ved talrige Undersøgelser, men den største Del af de Analyser, der ere udførte i denne Retning, ere dog — lige indtil den Tid, da Forchhammer offentliggjorde sin Afhandling om Søvandet — temmelig værdiløse, da de ialmindelighed er behæftede med altfor store Feil til at kunne have nogen Betydning fra et nyere Standpunkt betragtet. De talrige og fortrinlige Undersøgelser, Forchhammer har udført for at komme til Klarhed i denne Sag viser tydelig, at man skal arbeide med stor Omhyggelighed, hvis ikke Feilene ved Analysen skal blive større end de smaa Variationer i Havets Sammensætning. Denne udmærkede Forsker har undersøgt 180 Vandprøver fra de forskjellige Dele af Verdenshavet og udført sine Analyser med en Grundighed og Nøiagtig-

On the Solid Matter in Sea-Water.

The first of the numerous works on ocean-water date from the close of the last century; and the branch of the subject which, to the earlier authors, would appear of paramount importance, was naturally the determination of the total amount of salt in sea-water, or the equivalent specific gravity of the latter, in all parts of the globe.

On instituting observations with this object in view, it soon became apparent — to the extent at least for which the limited means of analysis then known sufficed — that the proportion of salt in ocean-water was not subjected to other disturbing influences than such as could be readily traced to physical causes: for instance, dilution, in the Arctic regions, from the melting of enormous masses of ice. And the remarkable uniformity prevailing in the proportion of the total amount of salt, was plainly in favour of the hypothesis, that a like unvarying relation should subsist between the different constituents. The first experiments to determine the nature of sea-water, did not indeed give results that would now be held to exhibit close agreement; and yet Marcet (Phil. trans. 1822) was led to infer, that the variation in sea-water between lime, magnesia, chlorine, and sulphuric acid is relatively very trifling. That the ocean, so to speak, is a homogeneous fluid, or, that the variations exhibited in its composition represent magnitudes comparatively minute, — this view has since been repeatedly confirmed; but the greater part by far of the analyses performed to test it — previous to the date at which Forchhammer published his treatise on ocean-water — are of very questionable value, being most of them beset with errors, which, when viewed in the light of modern science, must be regarded as far too considerable to admit of our attaching any real importance to their results. The series of numerous and most successful experiments instituted by Forchhammer, sufficiently attest the care that is needed to keep the errors of analysis from exceeding in magnitude the inconsiderable variations occurring in the composition of sea-water. That distinguished observer examined no less than 180 samples of sea-water, collected

hed, der giver dem en ganske anden Betydning end de foregaaende.

Imidlertid kan der efter Forchhammers eget Udsagn gjøres nogle Indvendinger med Hensyn til Indsamlingen af disse Vandprøver, der for den største Del blev medbragt af forskjellige Søfarende, hvorved man ikke altid kunde have den nødvendige Garanti for deres omhyggelige Optagelse og Opbevaring. De Feilkilder, der paa denne Maade kunde opstaa, er maaske for en Del Skyld i de Uoverensstemmelser, der hist og her forekommer i Forchhammers Tabeller, hvor den overveiende Del af Tallene kun viser smaa og ialmindelighed let forstaaelige Differentser.

Forat skaffe Vand op fra Dybet har Forchhammer betjent sig af en tilproppet tom Flaske, som firedes ned til det bestemte Dyb, hvorved Vandet trykkede Proppen ind og fyldte Flasken. Ved Opbringelsen bragtes paa Grund af den tiltagende Varme og det aftagende Tryk Proppen atter paa sin Plads i Flaskens Munding. Man kan indse, at denne Fremgangsmaade ikke yder nogen tilstrækkelig Garanti for, at det optagne Vand virkelig stammer fra de bestemte Dybder; og Forchhammer indrømmer ogsaa villig dens Mangelfuldhed. De Dybvandsiagttagelser, Forchhammer paa denne Maade har anstillet, er ogsaa temmelig faatallige og indskrænker sig ialmindelighed til de høiereliggende Vandskikter, saa at man ikke deraf kan drage nogen Slutning med Hensyn til det Vand, der befinder sig i nærmere Berørelse med Havbunden. Der var jo en Mulighed for, at der her kunde gjøre sig andre Kræfter gjældende, f. Ex. Dyrelivet eller Havbundens Beskaffenhed, som kunde frembringe Forandringer i Havets Sammensætning.

Andre Kemikere har vistnok i den senere Tid behandlet dette Emne, og enkelte har ogsaa fundet, at Vandet fra Bunden har en noget anden Sammensætning end Vandet fra Overfladen, men disse Iagttagelser ere dog i flere Retninger saa ufuldstændige, at nøiere Undersøgelser maa være af Interesse.

Da den norske Nordhavsexpedition i Aarene 1876, 1877 og 1878 udgik paa sine forskjellige Togter forat undersøge Havet mellem Norge, Færøerne, Island, Jan Mayen og Spidsbergen i fysisk, zoologisk og kemisk Retning, var den rigelig udrustet med Redskaber til Indsamlingen af det respektive videnskabelige Materiale.

Til Opbevaring af Vandprøver var medtaget omkring 100 med Glasproppe forsynede Flasker (hvoraf de fleste rummede 2, nogle 5 Liter). Prøverne bleve dels tagne fra Overfladen, dels hentede fra Bunden og de mellemliggende Dyb ved Hjælp af en af Hr. Kaptain Wille konstrueret Vandhenter[1]. Ved Optagelsen af Vandet, saavelsom ved

[1] Tegning og Beskrivelse af dette Apparat findes i Tornøe's Afhandling om den i Søvandet opløste Luft.

in different parts of the ocean, performing his analyses with a thoroughness and rigorous precision that entitle them, as scientific results, to a far higher rank than can be claimed for any preceding observations.

Meanwhile, as Forchhammer himself admits, objections may be urged to the mode in which these samples of sea-water were drawn, the greater part having been brought home by seamen; and hence it was not always possible to obtain the necessary assurance, that due care had been taken in collecting and preserving them. To errors that may possibly have arisen from this source, we must, perhaps, partly ascribe the want of agreement met with here and there throughout Forchhammer's Tables, in which the figures generally exhibit but small differences easily accounted for.

To obtain deep-sea water, Forchhammer made use of a corked bottle, which was sunk to a depth at which the water, by reason of its greater pressure, forced in the cork and filled the bottle. On hauling in the line, the increased temperature and diminished pressure brought back the cork to its original position in the neck of the bottle. Now it is obvious, that, with this mode of drawing sea-water, there can be no absolute certainty of the sample obtained originating at the required depth; and Forchhammer readily grants its defectiveness. Indeed, the observations he has instituted with water drawn in this manner are comparatively few, and chiefly confined to the higher of the deep-sea strata; and hence nothing can be inferred from them respecting the water which is in close proximity to the bottom. Possibly, other agencies may be at work there; such, for instance, as depend on the presence of animal life or on the nature of the bottom, and which, in some way or other, might influence the composition of ocean-water.

Other chemists, too, have of late years investigated this subject; and, according to some, water from the bottom does differ slightly in composition from surface-water. Meanwhile, their results are in many respects so defective, that a record of more trustworthy observations, adapted to the present state of chemical science, will, it is believed, be found specially opportune.

The Norwegian North-Atlantic Expedition despatched in the years 1876, 1877, and 1878, for the physical, zoological, and chemical investigation of the tracts of ocean stretching between Norway, the Faröe Islands, Iceland, Jan Mayen, and Spitzbergen, was fitted out with the greatest care, being furnished with every aid and appliance deemed even remotely requisite for the attainment of the end proposed.

Among the chemical desiderata were comprised about 100 phials, with ground glass stoppers (some containing 2, and some 5 litres), in which to preserve samples of sea-water. The samples collected on the Expedition were obtained partly from the surface, partly from intermediate depths, and partly from the bottom, in an instrument[1] de-

[1] This apparatus is figured and described in Tornøe's Memoir on the air in sea-water.

Paafyldningen af Flaskerne, blev der anvendt den største Omhyggelighed, idet disse Operationer enten foregik under Opsigt af Hr. Tornøe, der fra 1877 var ansat som Expeditionens Kemiker, eller af mig, der i det følgende Aar deltog i Expeditionen, da Hr. Tornøe ikke alene kunde overkomme alle de kemiske Arbeider, som vare nødvendige under Reisen. De af os medbragte Vandprøver ere hentede nordenfor den nordlige Polarkreds; de øvrige, der ere tagne søndenfor denne, ere paa samme Vis indsamlede og opbevarede af Hr. Svendsen, der var Expeditionens Kemiker paa dens første Udflugt i 1876.

Alle de Arbeider, der ere udførte ombord, saasom Luftudkogninger, Bestemmelser af Kulsyren, Klormængden og den specifiske Vægt ere senere bearbeidede og diskuterede af min Ven Hr. Tornøe, der har overtaget den fysiskkemiske Del af Arbeidet, medens det for mig stod tilbage at underkaste de medbragte Vandprøver en kemisk Analyse med Hensyn til de øvrige faste Bestanddele.

Ved disse Undersøgelser har jeg nu sat mig som Formaal at udfinde, hvorvidt Forholdet mellem Søvandets Bestanddele er udsat for saa store Forandringer, at de lader sig paavise ved de nøiagtigste analytiske Methoder, og om man af de fundne Tal kan uddrage nogen Regel med Hensyn til de mulige Forskjelligheder i Søvandets Sammensætning. I dette Øiemed har jeg udelukkende lagt Vægten paa de af Havets Bestanddele, der for det første lader sig bestemme med den største Lethed og Sikkerhed, og for det andet — efter al Erfaring og Sandsynlighed — maa være de Stoffer, som fortrinsvis kan paavirkes af andre i Havet forekommende Kræfter. Med dette Formaal for Øiet maa man nærmest henvende sin Opmærksomhed paa Kalk, Magnesia, Svovlsyre og Klor. Natron, Kali og de i mindre Mængde forekommende Baser og Syrer har med Hensyn til det foreliggende Spørgsmaal liden eller ingen Interesse, da de ikke kan bestemmes med den nødvendige Nøiagtighed. Hellerikke kan man for Alkaliernes Vedkommende tænke sig, at de skulde være synderlig afhængige af fremmede Paavirkninger, uden forsaavidt som en Variation i Klornatrummængden, der jo udgjør den overveiende Del af Havsaltet, vilde være ensbetydende med en tilsvarende Forandring i Vandets Egenvægt. Da der imidlertid er stor Uoverensstemmelse mellem de Tal, der af forskjellige Kemikere er fundne for Kalimængden i Søvandet, har jeg for Sammenlignings Skyld bestemt denne Bestanddel i nogle Vandprøver fra forskjellige Punkter af Havet.

Blandt de Salte, der forekomme i mindre Mængde i Søvandet, har især deleshed den kulsure Kalk været Gjenstand for Kemikernes Opmærksomhed. Mange har bestemt denne Forbindelse ved at koge en vis Portion af Søvandet i længere Tid — under stadig Erstatning af det fordampede Vand — og derpaa veie det udskilte Bundfald. Ved at analysere dette har jeg imidlertid ikke fundet Spor af

vised by Captain Wille, R. N. When drawing the water and filling the phials, the greatest care was taken, these simple but delicate operations having been invariably performed in the presence either of Mr. Tornøe (since 1877 chemist to the Expedition) or of myself, who the following year went out as assistant-chemist, Mr. Tornøe not being equal to all the chemical work that had to be done on the last cruise. The samples of sea-water brought home by us on the return of the Expedition, were all collected north of the Arctic circle; those from the first cruise, in 1876, having been similarly obtained and preserved by Mr. Svendsen, the gentleman originally appointed chemist to the Expedition.

All chemical work done on board, viz. determinations of air, carbonic acid, chlorine, and specific gravity, has been since critically reviewed and tested by my friend Mr. Tornøe, who undertook to work up the physico-chemical details, while I have analysed the various samples of sea-water with a view to determine their solid constituents.

My object with this investigation, has been to ascertain, if possible, whether the relation subsisting between the component parts of sea-water varies sufficiently to admit of determining its fluctuations by the most exact analytical methods; and whether, in that case, it were not possible from the results attained to deduce some definite rule regulating such assumptive differences in the composition of sea-water. To this end, I have exclusively laid weight on those constituents of ocean-water which, first, admit of being determined with the greatest accuracy and facility, and which, secondly, — as is indicated alike by experience and probability, — must be the substances specially acted upon by the forces operating in sea-water. And those substances are chiefly lime, magnesia, sulphuric acid, and chlorine. Soda, potash, and the bases and acids occurring in quantities comparatively small, have, as affecting this question, little or no interest, since they cannot be determined with sufficient exactness. Nor is it likely that the proportion of alkalies is dependent in any considerable degree upon extraneous influence, save inasmuch as a variation in the amount of chloride of sodium, which constitutes, we know, by far the greater part of the salts in sea-water, would imply a corresponding change in the specific gravity of the water. Meanwhile, as the figures computed by divers chemists for the proportion of potash in sea-water, exhibit a remarkable want of agreement, I have determined that substance in several of the samples of water collected from different parts of the ocean.

Among the salts which sea-water contains in small quantities only, carbonate of lime is that which has most attracted the attention of chemists. Its relative proportion has been repeatedly determined, by boiling for a considerable time a given quantity of sea-water, — the loss from evaporation being supplied as it arises, — and then weighing the precipitate. On analysing this deposit, I have

Kalk[1]. Dette Bundfald viste sig at bestaa af Magnesia foruden en Smule Jern og Fosforsyre og neppe mærkelige Spor af Kulsyre. Inddamper man derimod en Liter Søvand til dens halve Volum, saa danner der sig et Bundfald, som bestaar af kulsur Kalk og Gibs og kun indeholder smaa Mængder Magnesia. Men hvorvidt den kulsure Kalk, som i dette Tilfælde udskiller sig, virkelig fra Begyndelsen af har været opløst som saadan i Søvandet, kan naturligvis ikke afgjøres ved dette Forsøg. Tvertimod synes det med megen Rimelighed at fremgaa af Hr. Tornøe's Undersøgelser over Kulsyren i Søvandet, at denne fortrinsvis maa være bundet til Natron som dobbelt kulsurt Salt.

Ved videre Inddampning af Søvandet udskilles Gips og Klornatrium. Endnu efterat Hovedmassen af Kogsaltet har afsat sig, indeholder Moderluden alle de Kali- og Magnesiasalte, der fra Begyndelsen af har været tilstede i Vandet. I en saadan Moderlud fra 20 Liter Søvand lykkedes det mig at paavise Jod efter den af Koetstorfer[2] angivne Methode. Ved Afkjøling under 0° udskilte den Krystaller af svovlsurt Natron, ved høiere Temperatur svovlsur Magnesia.

Forchhammer angiver i sin Afhandling om Søvandet, at han flere Gange har fundet Svovlvandstof i de hjemsendte Prøver. Han tilføier imidlertid, at denne Forbindelse muligens kan være opstaaet ved en mindre omhyggelig Rensning af Flaskerne; men i enkelte Tilfælde føler han sig dog forvisset om, at den maa have dannet sig af Søvandets egne Bestanddele. Jeg har aldrig kunnet opdage den karakteristiske Lugt af denne Gas ved Aabningen af de fra Expeditionen medbragte Vandprøver. Selv nogle af disse, der undtagelsesvis vare blevne opbevarede i almindelige, med Korkpropper forsynede, Flasker og først aabnedes efter et Par Aars Forløb, befandtes at være fuldkommen lugtfrie.

Efter Forchhammer's Mening skulde Svovlvandstoffet have dannet sig ved Oxydation af de organiske Stoffe paa de svovlsure Saltes Bekostning. Forat bestemme Søvandets organiske Bestanddele benyttede Forchhammer Kogning med Kamæleon, og indførte derved en Methode, der som bekjendt senere har faaet en udstrakt Anvendelse med Hensyn til Drikkevand.

Han tilsatte Søvandet saameget af en bekjendt Opløsning af overmangansur Kali, at det efter et Opkog og Henstand i 12 Timer beholdt en rødlig Farve. Den i Overskud tilsatte Kamæleon fandtes ved at bestemme den Mængde af denne, der var nødvendig forat frembringe samme Farve i det samme Volumen rent Vand. Ved at anvende denne Methode har jeg fundet, at 100 Kc. Søvand ialmindelighed affarver 0.0005 Gr. overmangansur Kali, hvad der omtrent skulde svare til 0.0025 pCt. organiske

[1] Sammenlign Tornøe's Afhandling om Kulsyren i Søvandet.
[2] Zeitschrift für anal. Chemie, 1878, S. 305.

failed however to detect the slightest trace of lime.[1] The said deposit was found to consist of magnesia, along with a little iron and phosphoric acid, and hardly appreciable traces of carbonic acid. If, on the other hand, a litre of sea-water be reduced by boiling to half its volume, the precipitate will consist of carbonate of lime and gypsum, the proportion of magnesia being comparatively small. But whether the carbonate of lime precipitated in this case was originally present as such in the water, is a question which cannot be decided by this experiment. Judging, however, from the results of Mr. Tornøe's observations on the carbonic acid present in sea-water, that gas may with good reason be inferred to occur chiefly in combination with soda as a bicarbonate.

On further evaporation of the sea-water, gypsum and chloride of sodium are deposited; and even after the bulk of the chloride of sodium has been precipitated, the mother-liquor contains all the salts of potash and magnesia originally present in the water. In mother-liquor of this description, obtained from 20 litres of sea-water, I succeeded in detecting iodine, by the process described by Koetstorfer.[2] On reducing the temperature, sulphate of soda was deposited; on raising it, sulphate of magnesia.

In the treatise on ocean-water, Forchhammer records his having frequently met with hydrosulphuric acid in the samples of sea-water sent him; and this compound may, he thinks, in most cases, be traced to impurities in the bottles; though in some he feels convinced it had formed from the constituent parts of the sea-water itself. I did not however in any case detect the fætid smell characteristic of that gas, when opening the numerous phials brought home with the Expedition. Certain of the samples even exceptionally preserved in common corked bottles, and allowed to stand over for the space of two years, proved to be quite inodorous.

According to Forchhammer, hydrosulphuric acid is formed by the oxidation of organic matter, at the cost of the sulphates. In order to determine the organic elements of sea-water, Forchhammer boiled the latter with permanganate of potash, thus devising a process which has since been extensively adopted for the determination of organic matter in drinking-water.

He added to the sea-water a solution of permanganate of potash, of known strength, sufficient to give it, on being boiled and suffered to stand over for the space of 12 hours, a reddish colour. The excess of permanganate of potash was found by determining the proportion of that substance necessary to produce the same colour in an equal volume of pure water. Adopting this method, I found that 100^{cc} generally sufficed to discolour 0.0005^{gr} of permanganate of potash, which nearly corresponds to 0.0025^{gr}

[1] *Vide* Tornøe's Memoir "On the Carbonic Acid in Sea-Water."
[2] Zeitschrift für anal. Chemie, 1878, S. 305.

Stoffe. Dette er mindre end Halvdelen af, hvad Forchhammer har fundet som Middeltal for Havets organiske Bestanddele, men stemmer ganske godt overens med nogle Bestemmelser, der i den senere Tid er udført af Professor Almén[1] i endel Vandprøver fra Omegnen af Spidsbergen. Almén anvender hertil den samme Methode som ved Drikkevand, idet han tilsætter Søvandet Svovlsyre og ved gjentagne Kogninger med Kamæleon oxyderer de organiske Stoffe. Forat forhindre den skadelige Virkning af Klormetallerne fortynder han det iforveien med destilleret Vand. Paa denne Maade finder han, at 100 Kc. Ishavsvand indeholder 0.0018—0.0038 Gr. organiske Substantser. Nordsøen, Skagerak og Kattegat skulde efter hans Undersøgelser indeholde en større Mængde organiske Bestanddele, men dog ikke saameget som det ferske Vand fra Floder og Indsøer, hvilket viser, at Søvandet ikke fremfor dette er begavet med nogen særegen reducerende Evne. Paa mange af de fra Expeditionen medbragte Flasker havde der i Tidens Løb udskilt sig et ubetydeligt fnokket Bundfald af organiske Stoffe, der under Mikroskopet viste sig at indeholde Diatomeer. Filtratet forholdt sig imidlertid ganske ordinært ligeoverfor den overmangansure Kali.

Til Bestemmelsen af Kalk, Magnesia og Svovlsyre i Havvandet har jeg betjent mig af de almindelige velbekjendte Methoder; men de forberedende Undersøgelser, jeg har gjort forat forsikre mig om Paalideligheden af disse, har vist mig, at de ikke altid giver saa nøiagtige og overensstemmende Resultater, som ere nødvendige for et Arbeide som det foreliggende, hvis man ikke i enkelte Retninger tager nogle Forsigtighedsregler, der ere altfor løst omtalte i de analytiske Haandbøger. Jeg vil derfor i det følgende gaa lidt nærmere ind paa de Fremgangsmaader, jeg har brugt forat erholde de nøiagtigste Bestemmelser.

Kalk og Magnesia.

Til disse Bestemmelser afveiedes $^1/_4$ Liter Søvand. Efterat Magnesiaen ved Tilsætning af omtrent 25 Kc. koncentreret Saltsyre og derpaa følgende Neutralisation med koncentreret Ammoniakopløsning indtil et ubetydeligt Overskud var forhindret fra at falde ud, blev Kalken i Kulden bundfældt med et Overskud af oxalsur Ammoniak. Efter en Nats Henstand frafiltreredes Bundfaldet, opløstes i varm Saltsyre og udfældtes atter i Koghede med Ammoniak og nogle Draaber oxalsur Ammoniak. Efter 12 Timers Forløb blev Bundfaldet bragt paa Filtrum og bestemt som Ætskalk. Tilstedeværelsen af Klornatrium har ingen skadelig Indflydelse paa Kalkbestemmelsen, men synes tvertimod at bidrage til en smuk krystallinsk Udfældning af den oxalsure Kalk. Følgende Kontrolbestemmelser viser Analysernes Paalidelighed:

[1] Svenska läkaresälskapets nya handlingar. Ser. II, del III, Stockholm 1871.

organic matter. This is less indeed than half the proportion Forchhammer gives as the mean for the organic elements of ocean-water; it agrees, however, pretty closely with certain determinations performed some time since by Professor Almén[1] with samples of sea-water collected in the region of Spitzbergen. Almén resorts to the method adopted for drinking-water, mixing sulphuric acid with the water, in which, after repeated boiling with permanganate of potash, the organic matter will be oxidized. To counteract the injurious effect of the chlorides, he dilutes the samples beforehand with distilled water. In this manner he finds that 100^{cc} of Arctic sea-water contain from 0.0018^{gr} to 0.0038^{gr} of organic matter. According to his observations, the proportion is somewhat greater in the North Sea, the Skagerak, and the Cattegat, though not equal to that in the water of rivers and lakes, which shows that sea-water, compared to the latter, cannot be possessed of any special reductive property. In some of the phials brought home with the Expedition, had formed a thin precipitate of organic matter, which, when viewed under a microscope was found to contain Diatoms. The filtered solution, however, behaved as usual when treated with permanganate of potash.

For determining the potash, magnesia, and sulphuric acid in ocean-water, I have adopted the ordinary, well-known methods; but the series of preliminary experiments which I instituted with a view to test their trustworthiness, has convinced me that they do not always give results sufficiently accurate and congruous to warrant their adoption here, unless indeed accompanied by certain precautions too briefly dismissed in analytical class-books. I shall therefore in the context dwell more at large on the several modes of operation by which I have sought to obtain the most accurate determinations.

Lime and Magnesia.

For determining these substances, a quarter of a litre of sea-water was first weighed. After guarding against the precipitation of the magnesia, by adding about 25^{cc} of concentrated hydrochloric acid, and then neutralising with a concentrated solution of ammonia, in slight surplus, the lime was precipitated cold, by means of oxalate of ammonia in excess. Next morning the precipitate was filtered off, dissolved in warm hydrochloric acid, and again precipitated, at the boiling point, with ammonia and a few drops of oxalate of ammonia. After 12 hours, the solution was filtered, and the precipitate weighed, as caustic lime. The presence of chloride of sodium has no disturbing effect on the lime-determinations; nay, it apparently contributes towards the beautiful crystalline precipitation of the oxalate of lime. The following test-determinations vouch for the accuracy of the analyses: —

[1]. Svenska läkaresälskapets nya handlingar. Ser. II, del III, Stockholm 1871.

I No. 1 fandtes 0.0595 og 0.0602 pCt. CaO.
I „ 11 — 0.0580 „ 0.0590 „ „
I „ 26 — 0.0590 „ 0.0596 „ „
I „ 33 — 0.0585 „ 0.0595 „ „
I „ 34 — 0.0590 „ 0.0593 „ „
I „ 35 — 0.0585 „ 0.0588 „ „
I „ 36 — 0.0577 „ 0.0579 „ „
I „ 49 — 0.0578 „ 0.0582 „ „
I „ 50 — 0.0583 „ 0.0588 „ „

Den største Differents mellem Bestemmelserne i et og samme Vand er altsaa 0.001 pCt.

Til Bestemmelsen af Magnesia inddampedes de to Filtrater fra Kalkfældingerne i en Platinskaal til omtrent 150 CC. og bundfældtes derpaa med fosforsurt Natron og en saa stor Mængde koncentreret Ammoniakopløsning, at denne kom til at udgjøre omtrent 1/3 af Vædskens Volum. Iagttager man ikke den Forsigtighedsregel at tilsætte et saadant Overskud af Ammoniak, vil man let faa uoverensstemmende Resultater. Ved at anvende forskjellige Ammoniakmængder fandt jeg i et og samme Vand følgende Tal for Magnesia.

Med 9 Dele Vædske og 1 Del konc. Amm. 0.2044 pCt. MgO.
„ 5 „ — „ 1 „ — 0.2061 „ „
„ 2 „ — „ 1 „ — 0.2140 „ „

I et andet Vand fandtes paa samme Maade:

Med 9 Dele Vædske og 1 Del konc. Amm. 0.2054 pCt. MgO.
„ 2 „ — „ 1 „ — 0.2112 „ „

Nødvendigheden af at tilsætte et saadant Overskud af Ammoniak for at faa en nøiagtig Bestemmelse af Magnesia efter denne Methode er altfor lidet fremhævet i de analytiske Lærebøger. Rimeligvis er denne mindre paaagtede Feilkilde Grunden til, at flere Kemikere har fundet meget uoverensstemmende og lave Tal for Magnesia i Søvandet. Forchhammer, hvis Resultater med Hensyn til Kalk- og Magnesiamængden stemmer godt overens med mine Analyser, inddamper Filtratet fra den fosforsure Ammoniakmagnesia til Tørhed og faar ved Opløsning af Residuet i Ammoniak altid en liden Rest af det fosforsure Salt. En saadan Inddampning er imidlertid ikke nødvendig, naar man blot før Fældningen koncentrerer Vædsken til det mindst mulige Volum og tilsætter det nødvendige Overskud af Ammoniak. Naar Bundfaldet derpaa efter 24 Timers Henstand frafiltreres, giver Filtratet ved Inddampning ingen Rest af fosforsur Ammoniakmagnesia.

Men uagtet disse Forholdsregler kan Magnesia ikke bestemmes med samme Sikkerhed i Havvandet, som Kalk og Svovlsyre. Nedenstaaende Tal viser Differentserne mellem Kontrolbestemmelserne:

I No. 33 fandtes 0.2160 og 0.2200 pCt. MgO.
I „ 35 — 0.2180 „ 0.2207 „ „
I „ 36 — 0.2173 „ 0.2180 „ „
Største Differents = 0.004 pCt.

In Sample 1 the proportion was 0.0595 and 0.0602 p.ct. CaO.
In — 11 „ „ „ 0.0580 „ 0.0590 „ „
In — 26 „ „ „ 0.0590 „ 0.0596 „ „
In — 33 „ „ „ 0.0585 „ 0.0595 „ „
In — 34 „ „ „ 0.0590 „ 0.0593 „ „
In — 35 „ „ „ 0.0585 „ 0.0588 „ „
In — 36 „ „ „ 0.0577 „ 0.0579 „ „
In — 49 „ „ „ 0.0578 „ 0.0582 „ „
In — 50 „ „ „ 0.0583 „ 0.0588 „ „

Hence the greatest difference between any two determinations with the same sample of water is 0.001 per cent.

For determining the magnesia, the two solutions from which the lime-precipitates had been filtered off were evaporated in a platinum dish to about 150^{cc}, and then treated, for precipitation, with phosphate of soda, and with a concentrated solution of ammonia measuring one-third of the volume of the fluid. Unless ammonia be added in such excess, there is a risk of obtaining incongruous results. On treating different quantities of the fluid with the same proportion of ammonia, I found the following figures for magnesia.

With 9 parts of fluid and 1 part of conc. amm. 0.2044 p.ct. MgO.
„ 5 „ „ „ „ 1 „ „ — 0.2061 „ „
„ 2 „ „ „ „ 1 „ „ — 0.2140 „ „

In another sample of water, the percentage thus found was —

With 9 parts of fluid and 1 part of conc. amm. 0.2054 p.ct. MgO.
„ 2 „ „ „ „ 1 „ „ — 0.2112 „ „

The necessity, with this method, of adding ammonia in so great excess, to ensure a satisfactory determination of magnesia, has not been sufficiently emphasized in analytical class-books; and to this comparatively disregarded source of error, may no doubt be attributed the fact of divers chemists having obtained for magnesia, in their analyses of sea-water, results alike incongruous and low. Forchhammer, whose lime and magnesia determinations exhibit close agreement with my own, evaporates to dryness the solution from which the double phosphate of ammonia and magnesia has been filtered, and can, on dissolving the residue in ammonia, invariably detect traces of the phosphate. Meanwhile, evaporation does not constitute a necessary phase of the process, provided the fluid, previous to precipitation, be concentrated to the least possible volume, and then treated with ammonia in due excess; for, on the precipitate, after 24 hours, being filtered off, the solution, if evaporated to dryness, will not leave a trace of double phosphate of ammonia and magnesia.

But, even assuming every precaution, the magnesia in sea-water does not admit of being determined with the same degree of accuracy as do lime and sulphuric acid. The annexed figures show the extent to which the test-determinations were found to differ.

In Sample 33 the proportion was 0.2160 and 0.2200 p.ct. MgO.
In — 35 „ „ „ 0.2180 „ 0.2207 „ „
In — 36 „ „ „ 0.2173 „ 0.2180 „ „
Greatest difference: 0.004 per cent.

Svovlsyre.

Til denne Bestemmelse har jeg afveiet omtrent 100 Gr. Søvand, som tilføiedes 8—10 Draaber koncentreret Saltsyre og i Koghede bundfældtes med en Klorbariumopløsning, der tilsattes af en Bürette for at forhindre et skadeligt Overskud. Flasken med Bundfaldet hensattes derpaa i Kulden, og Filtreringen foretoges først efter 12 Timers Forløb.

Paa denne Maade erholdtes ved Kontrolbestemmelserne følgende Tal:

I	No.	6	fandtes	0.2226	og	0.2236	pCt.	SO_3.
I	„	11	—	0.2145	„	0.2155	„	„
I	„	12	—	0.2219	„	0.2221	„	„
I	„	40	—	0.2176	„	0.2195	„	„
I	„	42	—	0.2156	„	0.2165	„	„

Største Differents = 0.0019 pCt.

Hvis man lader Bundfaldet afsætte sig i Varmen og derpaa frafiltrerer det ved den samme Temperatur, taber man altid en Del af den svovlsure Baryt, da dette Salt er noget opløseligt i varmt Søvand, og Filtratet udskiller derfor ved Afkjøling og Henstand et krystallinsk Bundfald af Tungspath. Denne Opløselighed skyldes det tilstedeværende Klornatrium. Jeg har overbevist mig om dette ved sammenlignende Forsøg med en Kogsaltopløsning af en Koncentration, der omtrentlig svarede til Søvandets. Tilsættes en Smule Svovlsyre eller svovlsur Kali til et vist Kvantum af denne Opløsning, vil der trænges mere af en fortyndet Klorbariumopløsning for deri at frembringe Bundfald, end der er nødvendig til samme Volumen rent Vand, hvortil er tilsat den lige Mængde Svovlsyre. De Feil, der kan opstaa i Bestemmelserne, hvis man frafiltrerer Bundfaldet ved almindelig Vandbadtemperatur (80°—90°) er vistnok ikke betydelige, men giver sig dog klart tilkjende, da de ialmindelighed er flere Gange større end Differentserne mellem de ovennævnte Kontrolbestemmelser[1].

[1] Som Exempler kan anføres følgende Analyser:

							I Varmen:	*I Kulden:*
I	No.	20	fandtes	ved	Filtrering		0.2172	0.2204
I	„	37	—	„	—		0.2140	0.2194
I	„	38	—	„	—		0.2144	0.2183
I	„	44	—	„	—		0.2087	0.2120
I	„	46	—	„	—		0.2140	0.2205
I	„	48	—	„	—		0.2110	0.2150
I	„	49	—	„	—		0.2207	0.2215

Ved ikke at tage Hensyn til den svovlsure Baryts Opløselighed i varmt Søvand vil man altsaa faa en Feil, der ialmindelighed beløber sig til omtrent 0.004 pCt. R. Fresenius har (Zeitschrift für anal. Chemie 9, S. 52) undersøgt forskjellige Saltes opløsende eller forurensende Evne ligeoverfor den svovlsure Baryt og fundet, at Klornatrium ikke har nogen skadelig Indflydelse paa Svovlsyrebestemmelsen. Ved Analyser, der kræver en speciel Nøiagtighed, har altsaa dette blot sin Rigtighed under Forudsætning af, at Bundfaldet faar Anledning til at afsætte sig i Kulden. Hvorvidt Fresenius ved sine Forsøg har iagttaget denne Forsigtighedsregel, fremgaar ikke af hans Afhandling, men Differentsen mellem to Bestemmelser, han har udført med eller uden Indvirkning af Klornatrium, falder ialtfald til

Sulphuric Acid.

For determining this constituent, I weighed 100 gr of sea-water, and treated the fluid with 8—10 drops of concentrated hydrochloric acid, precipitation — at the boiling-point — being then effected with a solution of chloride of barium, which was gradually added from a burette, with a view to prevent injurious excess. The phial containing the solution was now removed to a cold room, where, after the lapse of 12 hours, the precipitate was filtered off.

The following are the results of the test-determinations: —

In	Sample	6	the proportion	was	0.2226	and	0.2236	p.ct.	SO_3
In	—	11	„	„	0.2145	„	0.2155	„	„
In	—	12	„	„	0.2219	„	0.2221	„	„
In	—	40	„	„	0.2176	„	0.2195	„	„
In	—	42	„	„	0.2156	„	0.2165	„	„

Greatest difference: 0.0019 per cent.

By allowing the precipitate to form at about the boiling-point, and then filtering it off at the same temperature, some of the sulphate of baryta — a salt partially soluble in warm sea-water — will be invariably lost; and hence a crystalline deposit of sulphate of baryta is observed in the filtered solution some time after its cooling. The solubility of the salt is due to the presence of chloride of sodium: of this I am convinced from comparative experiments with a solution of common salt, corresponding in concentration as near as may be to sea-water. Now, if to a given quantity of this solution be added a little sulphuric acid or sulphate of potash, it will require more of a diluted solution of chloride of barium to effect precipitation than is necessary for the same volume of pure water treated with the same proportion of sulphuric acid. True, the errors in determination that can result from filtering off the precipitate at the ordinary water-bath temperature (80° — 90°), are not great, — but they are quite appreciable, being many times greater indeed than the differences between the test-determinations alluded to above.[1]

[1] This will appear from the following results: —

					Filtered warm.	*Filtered cold.*		
In	Sample	20	the proportion	was	0.2172	0.2204	p.ct.	SO_3.
In	—	37	„	„	0.2140	0.2194	„	„
In	—	38	„	„	0.2144	0.2183	„	„
In	—	44	„	„	0.2087	0.2120	„	„
In	—	46	„	„	0.2140	0.2205	„	„
In	—	48	„	„	0.2110	0.2150	„	„
In	—	49	„	„	0.2207	0.2215	„	„

Hence, the error that arises from disregarding the solubility of sulphate of baryta in warm sea-water, will generally amount to 0.004 per cent. R. Fresenius has examined (Zeitschrift für anal. Chemie 9, S. 52) divers salts, with a view to ascertain their dissolving or contaminating properties in relation to sulphate of baryta, and has found chloride of sodium to have no disturbing influence on sulphuric acid determinations. This, then, in analyses craving exceptional accuracy will be found to hold good only in the event of the précipitate being allowed to form at a low temperature. Whether Fresenius had regard to this precaution, does not appear from his treatise; but the difference between two determinations he has performed, one with and one without the presence of chloride of sodium, is certainly in favour of sulphate

Kali.

Denne Bestemmelse, der kræver lang Tid og omstændeligt Arbeide, har jeg som før nævnt kun udført i nogle faa Vandprøver. Hertil har jeg anvendt omtrent 50 Gram Søvand og fraskilt Kalk og Magnesia efter den af Classen angivne Methode[1] med oxalsur Ammoniak, Alkohol og Eddikesyre. Filtratet blev inddampet til Tørhed, Ammoniaksalterne bortjagede og den tilbageblevne Saltmasse befriet fra Svovlsyre ved gjentagne Glødninger med et Overskud af Salmiak. De samlede Klorider blev derpaa opløste i Vand, overførte i Platindobbeltsalte og derpaa behandlede efter den Methode, der af Fresenius foreskrives til Bestemmelsen af Kali og Natron i Mineralvand. Det er imidlertid meget vanskeligt at faa al Svovlsyre fjernet ved Afdampning med Salmiak, og det fremstillede Kaliumplatinklorid indeholdt derfor altid Spor af svovlsure Salte. Der er saaledes en Mulighed for, at de fundne Kalimængder er noget for høie, skjønt Bestemmelserne i de forskjellige Vandprøver stemmer nogenlunde godt overens med hinanden.

Hvis man iforveien veier de samlede Klorider og derfra trækker den erholdte Klorkaliummængde, skulde man altsaa kunne finde Søvandets Klornatriumgehalt. Men da Kloriderne ialmindelighed ere forurensede med smaa Mængder Svovlsyre og Magnesia, der ikke er blevet fuldstændig fjernede ved de foregaaende Operationer, og Kulrester fra Ammoniaksaltenes Afdampning, vil man ved denne indirekte Bestemmelse faa altfor høie og uoverensstemmende Tal for Klornatrium. Man vil paa denne Maade ialmindelighed finde omkring 2.8 pCt. af dette Salt, medens man efter en anden Beregning, som senere skal omtales, neppe faar et Tal der overskrider 2.7 pCt.

Klor.

Med Hensyn til disse Bestemmelser, der er udførte ombord ved Titrering, henviser jeg til Hr. Tornøe's Afhandling om Saltmængden i Havet. For at bestemme Vandets samlede Saltgehalt har Hr. Tornøe inddampet en vis Portion deraf til Tørhed, glødet Residuet i nogle Minuter over en Bunsen's Lampe og derpaa ved Titrering korrigeret for den tabte Saltsyre. Efterat have udført disse Bestemmelser i nogle Vandprøver, har han paa Grundlag

Fordel for den svovlsure Baryts Opløselighed, om den end er for ubetydelig til at kunne tages med i Betragtning, naar den kun refererer sig til to Forsøg.

Den svovlsure Baryts Opløselighed i koldt Søvand er neppe paaviselig. Ved Tilsætning af en fortyndet Klorbariumopløsning fremkommer her Bundfaldet ligesaa hurtig som i en Opløsning af svovlsur Kali i rent Vand.

Klormagnesium forekommer i Søvandet i altfor ringe Mængde til at kunne have nogen skadelig Indflydelse paa Svovlsyrebestemmelsen. Jeg har desuden ved Forsøg overbevist mig om, at selv en mere koncentreret Opløsning af dette Salt ikke har nogen mærkelig Indvirkning paa Udfældningen af den svovlsure Baryt.

[1] Zeitschrift für anal. Chemie 1879, B. 4, S. 374.

Potash.

To determine this compound is a long and laborious task, and, as previously stated, I have performed it in only a few of the samples of sea-water. For this purpose, I precipitated, by Classen's method,[1] with oxalate of ammonia, alcohol, and acetic acid, the lime and magnesia in 50^{gr} of sea-water. The filtered solution was evaporated to dryness, the ammonia compounds volatilized, and the sulphuric acid in the residue got rid of by repeatedly heating to redness, with sal-ammoniac in excess. The several chlorides were then dissolved in water, transformed into double chloride of platinum, and then treated according to the method devised by Fresenius for determining potash and soda in mineral waters. Meanwhile, it is exceedingly difficult to get rid of all the sulphuric acid by evaporation with sal-ammoniac; and hence the double chloride of potassium and platinum invariably exhibited traces of sulphates. The amounts found for potash may therefore be a little too high, though the determinations performed with different samples of water agree pretty closely *inter se.*

Now, by weighing beforehand the several chlorides, and then subtracting the total amount of chloride of potassium, the proportion of chloride of sodium present in sea-water might accordingly be found. But, unfortunately, the chlorides are as a rule contaminated with small quantities of sulphuric acid and magnesia, that were not got rid of in the foregoing operations, along with a residue of carbonized organic matter resulting from the volatilization of the sal-ammoniac; and hence the figures thus indirectly computed for chloride of sodium will be alike incongruous and too high. This method will generally give about 2.8 per cent of the salt, whereas the amount by another mode of computation — to be afterwards noticed — does not exceed 2.7 per cent.

Chlorine.

As regards these determinations, which were performed on board by titration, the reader is referred to Mr. Tornøe's Memoir on the amount of salt in sea-water. To determine the total amount of salt in ocean-water, Tornøe evaporated a given quantity to dryness, kept the residue for a few minutes at a red-heat over one of Bunsen's lamps, and then determined by titration the loss of hydrochloric acid. After performing these deter-

of baryta's solubility, though too inconsiderable to be taken into account, referring as it does to only two determinations.

That sulphate of baryta is also soluble in cold sea-water, will hardly admit of proof. On adding a diluted solution of chloride of barium, the precipitate forms as rapidly as in a solution of sulphate of potash prepared with pure water.

Chloride of magnesium occurs far too sparingly in sea-water to admit of its disturbing the accuracy of sulphuric acid determinations. Besides, experiments have convinced me, that a comparatively concentrated solution of that salt does not appreciably affect the precipitation of sulphate of baryta.

[1] Zeitschrift für anal. Chemie 1879, B. 4, pag. 374.

deraf beregnet Saltgehalten i de øvrige ved Hjælp af Klormængden og den specifiske Vægt.

I den følgende Tabel har jeg ordnet Bestemmelserne efter Nummeret af de Stationer, hvor Vandprøverne er optagne. Bestanddelene er i Tabel I beregnede som Procenter af Søvandet. I Tabel II har jeg i Lighed med Forchhammer udregnet Bestanddelenes Forhold til Klormængden, naar denne sættes = 100.

Egenvægten af Søvandet er i Tabellen udtrykt ved 17°.5 C., sammenlignet med Vand af samme Temperatur.

De Tal, der er satte i Parenthes, er enten fundne ved Beregning eller udledede af Bestemmelser fra nærliggende Vandprøver.

minations with divers samples of sea-water, he computed from the results obtained the proportion of salt in the others, by means of the amount of chlorine and the specific gravity.

In the accompanying Table the numbers of the determinations are arranged to correspond with those of the Stations at which the samples of sea-water were collected. In Table I, the amounts are computed as percentages of the sea-water examined. In Table II, I have, in common with Forchhammer, computed the amounts as percentages of the proportion of chlorine, taking the latter at 100.

The specific gravities of the samples are reduced in the Table to 17°.5 C., as compared with pure water of the same temperature.

The figures parenthetically enclosed were either found by computation or deduced from determinations with samples drawn in some adjacent locality.

Table I.

No.	Stat. No.	Nordlig Bredde. (*North Latitude.*)	Længde fra Greenwich. (*Longitude from Greenwich.*)	Dybde i engl. Favne. (*Depth in English Fathoms.*)	Egenvægt ved 17.5°. (*Specific Gravity at 17.5°.*)	CaO.	MgO.	K_2O.	SO_3.	Cl.	Samlet Saltmængde. (*Amount of Salt measured.*)	Anmærkninger. (*Remarks.*)
1	3	61° 52′	5° 15.3′ E.	618	1.0266	0.0595 0.0602	0.2214		0.2202		3.51	Sognefjorden.
2	37	62 28.3	2 29 W.	690	1.0270	0.0573	0.2260		0.2242		3.56	
3	51	65 53	7 18	1163	1.02665	0.0575	0.2197		0.2192		3.52	
4	52	65 47.5	3 7	0	1.0268	0.0585	0.2249		0.2273		3.53	
5	52	65 47.5	3 7	515*	1.02675	0.0566	0.2190		0.2243		3.53	
6	52	65 47.5	3 7	1861	1.0267	0.0572	0.2202	0.0476 0.0470	0.2236 0.2226		3.52	
7		Nordpynt af Naalsø. Northern Extremity of Naalsø.		0	1.0269	0.0580					3.55	
8		63° 23′	20° 45′	0	1.0266	0.0575	0.2177		0.2190		(3.50)	Islands Sydkyst. South Coast of Iceland.
9	87	64 2	5 35 E.	498	(1.0266)	0.0594	0.2210		0.2220			
10	107	65 21	10 44	172		0.0574	0.2180		0.2197		(3.51)	
11	143	66 58	10 33	0	1.0257	0.0580 0.0590	0.2134 0.2134		0.2145 0.2155	1.899	3.42	
12	143	66 58	10 33	189	1.0265	0.0572	0.2230		0.2219 0.2221	1.956	3.52	
13	183	69 59.5	6 15	0	1.0267	0 0594	0.2240		0.2221	1.952	3.52	
14	183	69 59.5	6 15	1600*	(1.0267)	0.0560	0.2260					
15	184	70 4	9 50	1547	1.0265	0.0572	0.2219		0.2204 0.2206	1.935	3.50	
16	189	69 41	15 42	0	1.0263	0.0577				1.923	3.48	
17	189	69 41	15 42	860	1.0266	0.0587				1.931	3.50	
18	215	70 53	2 0 W.	0	1.0267	0.0561	0.2290		(0.2183)	1.945	3.52	
19	215	70 53	2 0	200*	1.0267	0.0586	0.2175		0.2230	1.945	3.52	
20	226	71 0	7 55	0	1.0261	0.0575	0.2159		0.2204	1.893	3.43	Nær Jan Mayen. Off Jan Mayen.
21	226	71 0	70 55	340	1.02635	0.0598	0.2202	0.0479	0.2226	1.936	3.49	
22	240	69 2	11 26	0	(1.0264)	0.0570	0.2240		0.2205		(3.48)	
23	245	68 21	2 5	0	1.0268	0.0589	0.2206		0.2197		3.53	
24	247	68 55	2 24 E.	0	1.0267	0.0582	0.2250		0.2215	1.954	3.53	
25	247	68 55	2 24	500*	1.0266	0.0586	0.2160		0.2226	1.927	3.53	
26	254	67 27	13 25	140	1.0267	0.0590 0.0596	0.2240		0.2221	1.931	3.51	Vestfjorden.
27	256	70 8.5	23 4	0		0.0312	0.1219		0.1246	1.118	2.02	
28	264	70 56	35 37	0	1.0264	0.0584	0.2184	0.0451	0.2187	1.929	3.49	
29	264	70 56	35 37	86	1.0266	0.0587	0.2218	0.0492	0.2187	1.934	3.51	
30	275	74 8	31 12	0	1.0265	0.0565	0.2170		0.2230	1.935	3.50	
31	293	71 7	21 11	0		0.0584				(1.909)	(3.45)	
32	293	71 7	21 11	95		0.0570				1.943	3.51	
33	295	71 59	11 40	0	1.02665	0.0595 0.0585	0.2160 0.2200		0.2235	1.942	3.52	
34	295	71 59	11 40	100*	1.0266	0.0593 0.0590	0.2232		0.2212	1.942	3.51	
35	295	71 59	11 40	600*	1.0265	0.0588 0.0585	0.2180 0.2207		0.2220	1.936	3.50	
36	295	71 59	11 40	1110	1.0266	0.0577 0.0579	0.2173 0.2180	0.0482	0.2200	1.934	3.51	
37	297	72 36.5	5 12	0	1.0262	0.0580	0.2203		0.2194	1.928	3.48	
38	297	72 36.5	5 12	1280	1.0263	0.0593	0.2215		0.2183	1.926	3.48	
39	300	73 10	3 22 W.	0	1.0247	0.0552	0.2037		0.2051	1.810	3.278	I Drivisen. Drift Ice.
40	303	75 12	3 2 E.	0	1.02615	0.0576	0.2153		0.2176 0.2195	1.914	3.46	
41	304	75 3	4 51	1735	2.0263	0.0577	0.2240		0.2218	1.940	3.49	
42	306	75 0	10 27	1334	1.0263	0.0587	0.2178		0.2156 0.2165	1.920	3.47	
43	323	72 54	21 51	223	1.0265	0.0586	0.2199		0.2250	1.933	3.50	
44	339	76 30	15 29	0	1.0254	0.0554	0.2102		0.2120	1.867	3.37	Spitsbergens Sydspids. Southern Extremity of Spitsb.
45	350	76 26	0 29 W.	0	1.0254	0.0555	(0.2155)		0.2144	1.872	3.37	Nær Isgrændsen. In close proximity to the Ice.
46	350	76 26	0 29	500*	1.0263	0.0563	0.2193		0.2205	1.922	3.48	
47	350	76 26	0 29	1686	1.0260	0.0573	0.2224		0.2193	1.916	3.45	
48	351	77 50	0 9	0		0.0570	0.2120		0.2150		(3.40)	
49	362	79 59	5 40 E.	0	1.02615	0.0578 0.0582	0.2156		0.2215	1.917	3.503 3.46	
50	362	79 59	5 40	459	1.0262	0.0588 0.0583	0.2165	0.0454	0.2194	1.922	3.47	
51	373	68 10	14 26	120	1.0260	0.0575	0.2230		0.2213			Isfjorden.

* Dette Mærke betegner de intermediære Dybder. — The Asterisk denotes Intermediate Depths.

gjøre Fordring paa nogen Nøiagtighed, viser den ialfald, at Forskjellighederne i Vandets specifiske Vægt i Forening med Feilene ved de enkelte Analyser er tilstrækkelige til at forklare de fleste Afvigelser i de fundne Magnesiamængder. De Uoverensstemmelser, der ikke kan udtydes paa denne Maade, er (ligesom ved Kalken) saa smaa og uregelmæssige, at der ikke kan tillægges dem nogen afgjørende Beviskraft.

Forat bedømme de Tal, der er fundne for Svovlsyren, maa man tage de samme Hensyn til Vandets specifiske Vægt som ved Magnesia. Men der maa tillige bemærkes, at Svovlsyrebestemmelserne er i Besiddelse af en langt større Paalidelighed, da Feilene ved de enkelte Analyser, saaledes som Kontrolforsøgene viser neppe overstiger 0.002 pCt. De største Afvigelser i de fundne Svovlsyremængder er 0.2160 og 0.2273 pCt. i to Vandprøver, hvis specifiske Vægt var 1.0263 og 1.0268. Omend disse Differentser for en Del kan skyldes de tilsvarende Forskjelligheder i Egenvægten, er de dog for betydelige til, at denne Forklaring kan være tilstrækkelig. Desuden findes der ogsaa nogle Vandprøver af samme specifiske Vægt, der i Svovlsyregehalten differerer 0.005—0.006 pCt., hvilket er formeget til at kunne betragtes som Feil i Analysen. Skjønt disse Uoverensssemmelser, der kun forekommer paa nogle faa Punkter, er endnu ubetydeligere end ved Magnesia, bliver de dog vanskeligere at forklare paa Grund af Bestemmelsernes større Paalidelighed.

Forat betragte dette og de foregaaende Spørgsmaal fra forskjellige Sider har jeg i den følgende Tabel opstillet Middeltallene for Kalk, Magnesia, Svovlsyre og Klor i Overfladen, Bunden og de mellemliggende Dyb. Jeg har tillige udregnet disse Bestanddeles Forhold til hinanden ved at sætte Klor eller Svovlsyre = 100.

	Overfladen.	Bunden.	Mellemliggende Dyb.	Gjennemsnitsgehalt for hele Havet.
Middeltal for Cl. . . .	1.930	1.933	1.934	1.932
— - Egenvægt	1.0265	1.0265	1.0266	1.0265
— - CaO . .	0.0576	0.0581	0.0577	0.0578
— - MgO . .	0.2205	0.2207	0.2200	0.2203
— - SO_3. . .	0.2211	0.2208	0.2223	0.2214
CaO : Cl (Cl = 100). .	2.98	3.01	2.98	2.99
MgO : Cl	11.42	11.42	11.37	11.40
SO_3 : Cl.	11.46	11.42	11.49	11.46
CaO : SO_3 (SO_3 = 100)	26.05	26.32	25.95	26.11
MgO : SO_3	99.73	99.95	98.96	99.55

Som der vil sees af den sidste Tabel, afviger Middeltallene for Kalk og Magnesia saa yderst ubetydelig fra hinanden, at disse Variationer ganske kan sættes ud af Betragtning.

with no pretensions to accuracy, will at all events show, that differences in specific gravity and errors of analysis generally suffice to account for the want of agreement in the computed amounts of magnesia; and when, as is the case with the lime, this cannot be so explained, the variation is alike too slight and too irregular to admit of its possessing any real demonstrative power.

When estimating the accuracy of the figures found for the sulphuric acid, no less regard must be had to the specific gravity of the water than with magnesia. It must also, however, be borne in mind, that the sulphuric acid determinations are distinguished by a far higher degree of accuracy, the errors of analysis scarcely exceeding 0.002 per cent. The most considerable differences in the results for sulphuric acid — computed from two samples of water, specific gravity respectively 1.0263 and 1.0268 — amount to 0.2160 and 0.2273 per cent. True, this diversity can be partly ascribed to a corresponding deviation in specific gravity; but they are much too considerable to be thus accounted for. Besides, some of the samples with the same specific gravity differ in their proportion of sulphuric acid to the extent of 0.005, or 0.006 per cent, — too considerably, therefore, for the discrepancy to be regarded as a mere error of analysis. This want of agreement, though referring to water from a few localities only, and less considerable even than that in magnesia, is nevertheless difficult to explain, by reason of the greater accuracy of the determinations.

With a view to the better apprehension of this and the foregoing questions, I have tabulated the mean amounts of lime, magnesia, sulphuric acid, and chlorine in water from the surface, from intermediate depths, and from the bottom. I have likewise estimated the relative proportion of these compounds, with 100 equivalents of chlorine or sulphuric acid as the standard of computation.

	Surface.	Bottom.	Inter. Depths.	Mean Value.
Mean Value Chlorine	1.930	1.933	1.934	1.932
„ „ Sp.Gravity	1.0265	1.0265	1.0266	1.0265
„ „ CaO . .	0.0576	0.0581	0.0577	0.0578
„ „ MgO . .	0.2205	0.2207	0.2200	0.2203
„ „ SO_3. . .	0.2211	0.2208	0.2223	0.2214
CaO : Cl (Cl = 100). .	2.98	3.01	2.98	2.99
MgO : Cl	11.42	11.42	11.37	11.40
SO_3 : Cl.	11.46	11.42	11.49	11.46
CaO : SO_3 (SO_3 = 100)	26.05	26.32	25.95	26.11
MgO : SO_3	99.73	99.95	98.96	99.55

As appears from the Table, the mean values for lime and magnesia vary so inconsiderably *inter se* that we may safely disregard these differences.

En nærmere Berørelse med Havbunden og dens dyriske Liv har altsaa ingen mærkbar Indflydelse paa Havets Sammensætning med Hensyn til disse Bestanddele. Middeltallene for Svovlsyre viser større Afvigelser end de tilsvarende for Magnesia, skjønt man skulde have ventet, at det Modsatte havde fundet Sted. Forskjellighederne er dog i dette Tilfælde ligesom i de foregaaende for ubetydelige til at kunne afgive noget bestemt Bevis for, at der virkelig existerer nogen tilsvarende Eiendommelighed i Havet. At Svovlsyregehalten i de mellemliggende Dyb skulde være høiere end ved Bunden og Overfladen, er en Antagelse, der *a priori* ikke har nogen Sandsynlighed for sig.

Jeg kommer senere muligens tilbage til disse Spørgsmaal angaaende Havets Beskaffenhed i Dybet, da jeg for Øieblikket er ifærd med at undersøge de Prøver, som under Expeditionens Dybdemaalinger optoges af Havbunden. Efter de foreløbige Resultater i denne Retning anser jeg mig imidlertid berettiget til at antage, at dette Dybvandsslam er af en temmelig ensartet Beskaffenhed.

Forat betragte de her foreliggende Bestemmelser fra et andet Synspunkt, har jeg i efterfølgende Tabel ordnet Middel- og Forholdstallene for Søvandets Bestanddele efter de Breddegrader, mellem hvilke Vandprøverne er optagne.

	80°—71°	71°—66°	66°—62°
Middeltal for Cl	1.929	1.937	
— - Egenvægt	1.0264	1.0265	1.0268
— - CaO	0.0580	0.0579	0.0577
— - MgO	0.2190	0.2219	0.2205
— - SO_3	0.2208	0.2210	0.2223
CaO : Cl (Cl = 100)	3.01	2.99	
MgO : Cl	11.35	11.45	
SO_3 : Cl	11.45	11.41	
CaO : SO_3 (SO_3 = 100)	26.27	26.20	25.95
MgO : SO_3	99.18	100.4	99.19

Middeltallene for Kalkmængden viser i denne Tabel den samme Uforanderlighed som i den foregaaende. Forskjellighederne ved Magnesia er derimod større, men i Betragtning af Analysens mindre Sikkerhed berettiger de ikke til nogen Slutning med Hensyn til et tilsvarende Forhold i Havet. Svovlsyren har sit Maximum søndenfor den nordlige Polarkreds, hvor Middeltallet er 0.2223 pCt. Vandets høiere Egenvægt i denne Del af Havet staar maaske i Samklang med denne Forøgelse af Svovlsyremængden, skjønt man ved Sammenligning med Forchhammers Analyser af nærliggende Vandprøver, hvoraf ingen er hentede nordenfor den 62de Breddegrad, skulde tro, at Havet virkelig i disse sydligere Egne var i Besiddelse af en større Svovlsyregehalt. Forchhammer finder nemlig som Middeltal for Svovlsyren mellem den 60de og 62de Breddegrad 0.230 pCt. Men efter al Rimelighed skriver denne Uoverensstemmelse

Hence, close proximity to the bottom and the animal life prevailing there, is found to have no appreciable influence on the composition of ocean-water, — as regards, at least, this division of its constituents. The mean values for sulphuric acid exhibit greater variation than the figures computed for magnesia, though there was reason to expect the reverse. But here also, as in the case previously noticed, the differences are much too small to admit of their furnishing conclusive proof of some corresponding peculiarity actually distinguishing the water of the ocean. That the proportion of sulphuric acid should be greater at intermediate depths than at the bottom and the surface, is, reasoning *a priori*, an improbable assumption.

Possibly I shall have occasion to resume the discussion of questions relating to the composition of the ocean at great depths, being at present engaged on the examination of the samples of the bottom brought up on the Expedition when deep-sea soundings were taken. Judging from the first results in that direction, this deep-sea ooze would appear to be comparatively uniform in composition.

With the object of presenting the determinations here described from another point of view, I have, in the following Table, arranged the mean and proportional values of the constituent parts of the sea-water according to the parallels of latitude within which the samples of bottom-water were collected.

	80°—71°	71°—66°	66°—62°
Mean Value Chlorine	1.929	1.937	
„ „ Specific Gravity	1.0264	1.0265	1.0268
„ „ CaO	0.0580	0.0579	0.0577
„ „ MgO	0.2190	0.2219	0.2205
„ „ SO_3	0.2208	0.2210	0.2223
CaO : Cl (Cl = 100)	3.01	2.99	
MgO : Cl	11.35	11.45	
SO_3 : Cl	11.45	11.41	
CaO : SO_3 (SO_3 = 100)	26.27	26.20	25.95
MgO : SO_3	99.18	100.4	99.19

The mean values here computed for lime exhibit the same uniformity as those in the preceding Table, whereas the differences in the proportion of magnesia are greater. But, if regard be had to the fact, that the analyses from which they were deduced are to a certain extent defective, their results, though comparatively incongruous, will not warrant inferring a similar peculiarity in the water of the ocean. The amount of sulphuric acid reaches its maximum south of the Arctic Circle, where the mean amount is 0.2223 per cent. The greater specific gravity of the water in this tract of the ocean may possibly be connected with this increase in the proportion of sulphuric acid, though a comparison with Forchhammer's analyses of samples collected in adjacent localities, none of which, however, lay north of the 62nd parallel of latitude, would seem to favour the assumption, that the ocean, in those southern regions, does really con-

sig fra en stadig Feil i hans Analyser, da han nemlig til Udfældning af Svovlsyren har benyttet sig af den salpetersure Baryt, hvorved man — som senere er bevist — faar et stærkt forurenset Bundfald.

Af den sidste og de foregaaende Tabeller fremgaar det, at fra hvilken Side man end ser alle disse Bestemmelser af Kalk, Magnesia og Svovlsyre, kan de ikke med Bestemthed bevise nogen Foranderlighed i Søvandets Sammensætning; men det bør tillige bemærkes, at de Afvigelser, der er vanskeligst at forklare, især deleshed fremkommer ved Svovlsyrebestemmelserne.

Den Antagelse, at Havet i hele sin Dybde er en ensartet Blanding, hvori den nøiagtigste kemiske Analyse neppe kan paavise nogen Forskjellighed, bekræftes ved de her foreliggende Undersøgelser i endnu høiere Grad end ved de tidligere. Jeg har nemlig ikke nogensinde fundet saa store Uoverensstemmelser som de, der paa enkelte Steder er fremkomne ved Forchhammers og andre Kemikeres Analyser.

Retter man nu Opmærksomheden paa de fortyndede Vandprøver, hvis Egenvægt er under 1.0260, vil man heller ikke her finde nogen Forandring i det konstante Forhold mellem Bestanddelene. Station 300, 339 og 350, hvor Egenvægt og Klorgehalt er formindskede ved nærliggende Ismassers Smeltning, viser en nøiagtig tilsvarende Forskjellighed for de øvrige Bestanddeles Vedkommende. I Station 143, der er beliggende i Nærheden af den norske Kyst, og hvis Overfladevand som følge heraf er noget fortyndet, har jeg ved to Bestemmelser fundet en temmelig høi Kalkgehalt, medens derimod Magnesia og Svovlsyre fuldkommen retter sig efter Klormængden. Dette fortjener maaske en Smule Opmærksomhed, da der jo er Omstændigheder, som taler for en Tiltagen af Kalkmængden ved Kysterne.

I Station 256, hvor Overfladevandets Saltstyrke er reduceret til 2.02 pCt., viser dog Forholdet mellem Bestanddelene saa smaa Afvigelser fra det almindelige, at disse fuldstændig kan forklares som Feil i Bestemmelserne, der ved Vandets Fortynding naturligvis taber i Nøiagtighed.

Kjender man Søvandets Klorgehalt, vil man af de i Tabellerne angivne Forholdstal kunne beregne de øvrige Bestanddele med saa stor Nøiagtighed, at de fundne Tal for Kalk, Magnesia og Svovlsyre kun undtagelsesvis vil differere mere end 0.002, 0.005 og 0.003 pCt. fra de direkte Bestemmelser i Tabel I.

Forat lette Sammenligningen med de tidligere Analyser har jeg i efterfølgende Tabel paa samme Vis som Forchhammer forbundet Klor og Svovlsyre med Kalk og Magnesia til de Salte, som i Almindelighed antages at forekomme i Søvandet. Al Kalk er regnet til Svovlsyre,

tain a larger quantity of sulphuric acid, since he found the proportion of that constituent between the 60th and 62nd parallels of latitude to be 0.230 per cent. But, in all probability, this incongruous result must be ascribed to a constant error in his analyses, precipitating as he did the sulphuric acid with nitrate of baryta, which — as will be afterwards shown — gives a much contaminated deposit.

From the last Table, it is sufficiently clear, that howsoever these determinations be regarded, they cannot be assumed to furnish absolute proof of a variable relation subsisting between the constituent parts of sea-water; and we must bear in mind, that of such differences as have hitherto defied the penetration of observers, the most striking refer to sulphuric acid determinations.

The hypothesis which assumes the Ocean to consist throughout its entire depth of one homogeneous fluid, in which the most accurate of chemical analyses shall fail to detect dissimilarity of composition, has received from the experiments here described probably stronger confirmation than from any that have gone before them. Indeed none of my own results exhibit a want of agreement so considerable as that met with in some of Forchhammer's and other chemists' analyses.

Again, passing to the diluted samples (with a specific gravity under 1.0260), no disturbance will be apparent in the constant relation subsisting between the component parts of the water. At Stations 300, 339, and 350, where the specific gravity and the proportion of chlorine are reduced by the melting, in the immediate vicinity, of large masses of ice, the other constituents exhibit a corresponding difference in amount. In two samples drawn at Station 143, in close proximity to the Norwegian coast, where the surface-water is accordingly somewhat diluted, I determined a comparatively large amount of lime, whereas the proportion of magnesia and sulphuric acid was in strict proportion to that of the chlorine. This result is, perhaps, deserving of notice, inasmuch as there are grounds for assuming the amount of lime to increase near the coast.

At Station 256, where the proportion of salt in the surface-water is reduced to 2.02 per cent, the disturbance in the normal relation subsisting between the several constituents was so slight, that it could be wholly accounted for in each case as an error of analysis, the determinations being by reason of the dilution of the water proportionately less accurate.

Given the amount of chlorine in sea-water, the other constituents may be calculated from the proportional values given in the Tables with such accuracy, that the figures found for lime, magnesia, and sulphuric acid will rarely differ more than 0.002, 0.005, and 0.003 per cent from the direct determinations set forth in Table I.

With a view to facilitate comparison with the earlier analyses, I have in the annexed Table, following the example of Forchhammer, combined chlorine and sulphuric acid with lime and magnesia, to form the salts which are generally assumed to occur in sea-water. Thus, all lime is

No.	$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaHCO_3$	NaCl	Sum.	Salt-gehalt.
21	0.0020	0.1423	0.2083	0.3581	0.0755	0.0175	2.691	3.49	3.49
28	0.0021	0.1389	0.2074	0.3558	0.0716	0.0157	2.670	3.46	3.49
29	0.0021	0.1396	0.2049	0.3645	0.0781	0.0165	2.678	3.48	3.51
36	0.0024	0.1370	0.2091	0.3509	0.0764	0.0164	2.694	3.49	3.51
50	0.0016	0.1399	0.2056	0.3515	0.0720	0.0170	2.678	3.46	3.47

Som Følge af den høiere Svovlsyregehalt. Forchhammer finder i Søvandet, bliver hans Tal for Klornatrium ogsaa noget forøget. I Vandprøver af samme Egenvægt og Saltgehalt. som de af mig undersøgte, erholder han som Middeltal 2.75. pCt. Klornatrium.

Efter Tabel III har det nordlige Ishav gjennemsnitlig en specifisk Vægt af 1.0265, og 100 Dele af Vandet indeholder:

CaO	MgO	K_2O	Cl	SO_3
0.0578	0.2203	0.0472	1.932	0.2214.

Som Middeltal for de i Havet forekommende Salte erholdes ifølge den sidste Tabel:

$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaHCO_3$	NaCl
0.002	0.1395	0.2071	0.3561	0.0747	0.0166	2.682

100 Dele af det faste Søsalt indeholder altsaa:

$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaCO_3$	NaCl
0.057	4.00	5.93	10.20	2.14	0.475	76.84.

Til Slutning vil jeg udtale min hjerteligste Tak til Hr. Professor Waage for den Hjælp, han paa flere Steder i mine Undersøgelser har ydet mig.

Kristiania, den 14de Februar 1880.

No.	$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaHCO_3$	NaCl	Total.	Prop. of Salt.
21	0.0020	0.1423	0.2083	0.3581	0.0755	0.0175	2.691	3.49	3.49
28	0.0021	0.1389	0.2074	0.3558	0.0716	0.0157	2.670	3.46	3.49
29	0.0021	0.1396	0.2049	0.3645	0.0781	0.0165	2.678	3.48	3.51
36	0.0024	0.1370	0.2091	0.3509	0.0764	0.0164	2.694	3.49	3.51
50	0.0016	0.1399	0.2056	0.3515	0.0720	0.0170	2.678	3.46	3.47

By reason of the greater proportion of sulphuric acid Forchhammer found in sea-water, his figures for chloride of sodium are neccessarily somewhat higher. In samples of water with precisely the same amount of salt as those examined by myself, he determined the mean proportion of chloride of sodium to be 2.75 per cent.

According to Table III, the specific gravity of the Norwegian Sea is 1.0265; and 100 parts of the water contain —

CaO	MgO	K_4O	Cl	SO_3
0.0577	0.2203	0.0472	1.932	0.2214.

The mean values, as computed by the last Table, for the salts occurring in ocean-water, are as follows: —

$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaHCO_3$	NCl
0.002	0.1395	0.2071	0.3561	0.0747	0.0166	2.682.

Hence, 100 parts of dry sea-salt contain —

$CaCO_3$	$CaSO_4$	$MgSO_4$	$MgCl_2$	KCl	$NaCO_3$	NaCl
0.057	4.00	5.93	10.20	2.14	0.475	76.84.

In conclusion, I beg to return Professor Waage my most sincere thanks for the assistance he kindly rendered me when instituting the observations recorded in this Memoir.

Christiania, Febr. 14th 1880.

Om Havbundens Afleiringer.

Blandt de mange videnskabelige Undersøgelser, der behandler Havets forskjellige Naturforhold, findes der kun faa, som har skaffet os nogen Kundskab om den kemisk-geologiske Beskaffenhed af de Afleiringer, der bedækker Bunden i de store Havbasiner.

Det kan neppe vække nogen Forundring, at vore Erfaringer i denne Retning endnu er meget begrændsede, naar vi erindrer, hvilke betydelige Hjælpemidler, der er nødvendige for at gjøre Havbunden paa de dybere Steder tilgjængelig for den videnskabelige Forskning.

Der er vistnok i Tidernes Løb samlet mange Bidrag til Læren om de Sedimenter, der har afleiret sig langs Kysterne i de grundere Dele af Havet,[1] men ved Mangel paa Materiale har vi været forhindrede fra at gjøre os noget klart Begreb om de lignende Dannelser i Oceanets store Dyb.

De mange videnskabelige Expeditioner, der har undersøgt Havet i forskjellige Retninger, har tildels ogsaa hentet Prøver op af Havbunden, men Observationerne dreier sig væsentlig om deres zoologiske Forhold.[2]

En planmæssig og alsidig Undersøgelse af Havbunden er først blevet iværksat af den britiske "Challenger"-Expedition (1872—1876). Det rige Materiale af Bundprøver, der ved denne Anledning er indsamlet, er endnu ikke paa langt nær bearbeidet, men Expeditionens foreløbige Meddelelser — ved Sir Wywille Thomson og Mr. John Murray[3] — har allerede vist os store og overraskende Resultater.

[1] Det mest omfattende Værk i denne Retning er: „Lithologie du fond des mers" par M. Delesse.

[2] Dr. Wallich: The North-Atlantic Sea-Bed. Preliminary Report of the Scientific Exploration of the Deep Sea in H. M. Surveying Vessel "Porcupine". 1869. (Being No. 121 of the Proceedings of the Royal Society). The "Valorous" Expedition. Reports by Dr. Gwyn Jeffreys and Dr. Carpenter. (From the Proceedings of the Royal Society, Vol. XXV, No. 173).

[3] Reports from the "Challenger". (From the Proceedings of the Royal Society, No. 107, 1868). "The Atlantic" by Sir Wyville Thomson.

On Oceanic Deposits.

Of the numerous scientific investigations undertaken to determine the physical conditions of the sea, very few have furnished us with trustworthy data concerning the chemico-geological nature of the deposits in the great ocean basins.

Nor is it surprising that our experience in that direction should as yet be very limited, if we call to mind by what elaborate and costly means the bed of the ocean can alone be rendered accessible to scientific research.

True, many valuable additions have from time to time been made to our knowledge of the sea-bottom and its surface-stratum of sedimentary matter in coastal localities where the water is comparatively shallow:[1] but no clear idea could, for want of samples, be formed of the deposits in the great depths of the ocean.

On one or two of the many scientific Expeditions despatched to investigate the sea in different parts of the world, samples of the bottom were indeed collected, though chiefly as a help towards determining, from the character of any organisms they might contain, the general biological features of the region explored.[2]

A systematic and comprehensive investigation of the ocean-bed was first attempted on the "Challenger" Expedition (1872—76). Much still remains to be done in working out its rich collection of samples; but the Preliminary Reports of Sir Wyville Thomson and Mr. John Murray[3] sufficiently attest that great and surprising results have been attained.

[1] The most comprehensive work on this subject is "Lithologie du fond des mers," by M. Delesse.

[2] Dr. Wallich: The North-Atlantic Sea-Bed. Preliminary Report of the Scientific Exploration of the Deep Sea in H. M. Surveying Vessel "Porcupine," 1869. (Being No. 121 of the Proceedings of the Royal Society). The "Valorous" Expedition. Reports by Dr. Gwyn Jeffreys and Dr. Carpenter. (From the Proceedings of the Royal Society, Vol. XXV, No. 173.)

[3] Reports from the "Challenger." (From the Proceedings of the Royal Society, No. 107, 1868.) "The Atlantic," by Sir Wyville Thomson.

Det europæiske Nordhav, der 1876, 1877 og 1878 var Gjenstand for den norske Expeditions Undersøgelser, kan i Udstrækning ikke maale sig med de store Verdenshave, men det frembyder ved sin Beliggenhed en i flere Retninger særegen Interesse.

Dette gjælder ikke mindst om dets geologiske Forhold. Naar vi tager disse i Betragtning, maa vi kunne gjøre os et Begreb om enkelte af de Betingelser, der er givne for Dannelsen af Bundens Afleiringer i dette Hav.

Vi finder det fra forskjellige Sider begrændset af Øer og Kontinenter, hvor glaciale og vulkanske Kræfter har været og endnu er i Virksomhed. Norge er vel et af de Lande, der fortrinsvis har været udsat for Istidens furende og afgnavende Evne, og Spidsbergen og Grønland befinder sig endnu i den glaciale Tilstand.

Medens vi altsaa i disse Lande kan iagttage Isens Virkninger i den nuværende og i den forbigangne Tid, har vi paa Øerne Island og Jan Mayen de vulkanske Kræfter repræsenterede i et lignende historisk Forhold. Jan Mayen er et nedlagt Værksted, hvor der ikke paa mange hundrede Aar har fundet noget større Udbrud Sted, men Islands Vulkaner fortsætter fremdeles sin Virksomhed.

Skjønt vi nu vanskelig kan gjøre os nogen Ide om, i hvor høi Grad de ovennævnte Naturkræfter kan bidrage til Havets Afleiringer, ved vi dog, at de begge spiller en medvirkende Rolle. Det er saaledes almindelig bekjendt, hvorledes Isen — understøttet af Bræelvene — formaar at bære det Materiale, den har erobret fra det faste Land, ud i Havet. Her naar den som Drivis ud til de fjerneste Egne. Det er ogsaa en Nødvendighed, at der ved Vulkanernes Virksomhed maa samle sig mange mineralske Stoffe paa Havbunden. At disse kan være af væsentlig Betydning for dens Afleiringer er — for de store Verdenshaves Vedkommende — godtgjort ved Mr. Murrays Undersøgelser.

Foruden de ovennævnte Kræfter har vi i Nordhavet ogsaa andre, der i fremtrædende Grad virker i den samme Retning. Beeren Eiland er saaledes et mærkelig Exempel paa, hvorledes Bølgerne til Fordel for Havets Sedimenter formaar at udgrave og afslide det faste Land.

Ved Betragtning af disse mest iøinefaldende Naturforhold kan vi gjøre os et Begreb om, hvorledes der udenfra kan tilføres Havet Materiale, men paa den anden Side ved vi ogsaa, at Dyrelivet ved sine kemiske Virkninger kan give mægtige Bidrag til de sedimentære Nydannelser. Hvorledes nu de forskjellige Kræfter virker i Forening, hvem der har en større og hvem der har en mindre Betydning, og hvad der er det endelige Resultat af deres Samvirken -- er Spørgsmaal, som vi ikke kan besvare, førend vi har hentet Materialet til vor Undersøgelse op fra selve Havbunden.

Ifølge Planen for den norske Nordhavsexpedition var der bestemt, at der paa alle de Stationer, hvor Dybdemaalinger foretoges, tillige skulde optages Prøver fra Bunden. For at anskueliggjøre de Redskaber, der tjente til

The Seas of Northern Europe scientifically investigated on the Norwegian Expedition in 1876, 1877, and 1878, though in point of extent they cannot compare with the great oceans of the globe, are yet, by reason of their geographical position, in many respects peculiarly attractive as a field of exploratory research.

And not least does this apply to their geological character, which, if rightly apprehended, cannot but afford a clew to some of the conditions determining the formation of sedimentary deposit over the bed of the North Atlantic.

The tract in question is bounded on several sides by islands and continents where glacial and volcanic agency has been and still continues in operation. Few regions of our planet can in like degree with Norway have been exposed to the furrowing and grinding action of glaciers during the great ice age; and Spitzbergen and Greenland are even now in a glacial state.

Thus, whilst the past and present effects of glacial action may be observed in those regions, the islands of Jan Mayen and Iceland exhibit a similar historic relation as regards volcanic agency. The former is, so to speak, a long since abandoned workshop, in which for hundreds of years there has been no considerable eruption, whereas the volcanoes of Iceland continue as active as ever.

Now, though we can hardly determine in what degree the said forces tend to increase oceanic deposits, we know that both play a co-operative part in their formation. Thus, for instance, it is a well-known fact, that the ice, in conjunction with glacier torrents, bears down all manner of *débris* to the ocean. From here it find its way as drift-ice to the most distant regions. Moreover, it is obvious that to volcanic agency must be ascribed the occurrence of many mineral substances present in oceanic deposit, of which they are shown by the results of Mr. Murray's investigations -- as regards at least the great ocean basins — to constitute an important feature.

But, apart from the action of glaciers and volcanoes, we have other potent forces operating with like effect in the North Atlantic. Thus, Beeren Eiland signally exemplifies the remarkable instrumentality of the waves in accumulating sedimentary deposit over the ocean-bed by excavating and wearing away the rocks of the shore.

A glance at these salient physical conditions will suffice to show from what extraneous sources oceanic deposit can be derived; and on the other hand, we know that animal life, so abundant in the waters of the sea, must largely contribute to such new formations. But how the several forces act in conjunction, what is the product of each, and what the joint result of their co-operation, — these are questions the bearing of which we cannot venture to infer till such time as samples of deposit shall have been brought up from the sea-bed itself.

Pursuant to the Scheme of Work for the Norwegian North-Atlantic Expedition, a sample of the bottom was, if possible, to be obtained at every sounding-station. The following extracts from "The Apparatus, and how used," one

kortfattet Oversigt over de forskjellige Sedimenters Fordeling i Havet — støttet til Iagttagelserne ombord og mine senere Undersøgelser.

Jeg maa her forudskikke den Bemærkning, at jeg i Mangel af andre Udtryk har valgt Benævnelsen "Ler" for alle de Slamdannelser, der efter Tørring opnaaede en vis Fasthed og Sammenhængskraft. Beskrivelsen af Bundprøvernes ydre Kjendetegn refererer sig væsentlig til deres Udseende i den tørrede Tilstand, saaledes som jeg ved mine Undersøgelser har havt dem. Det være foreløbig sagt, at det mest karakteristiske Mærke for de forskjellige Sedimenter er Farven, der væsentlig er betinget af den Oxydationsgrad, hvori de befinder sig.

I de grundere Dele af Havbunden langs Norges og Spidsbergens Kyster finder vi Bunden bedækket af et mere eller mindre plastisk Ler, der næsten altid er af en graa Farve. Blandingsdelenes Finhed og Biblandingen af grovere Materiale — i Form af Sand, Dyreskaller og lignende — er meget forskjellige i de talrige Prøver, der er indsamlede fra disse Egne af Havbunden. Dette Kystler gaar sjelden dybere ned end til 400—500 Favne (700—900 Meter).

Ved dette Dyb støder man ialmindelighed paa et brunt Ler, der bebuder Overgangen til det egentlige Oceansediment. I Begyndelsen af sin Optræden er dette brune Ler ofte temmelig sandholdigt og grovkornigt og indeholder kun faa Foraminiferer (Overgangsler); længere ud i Havet bliver det mere fint og ensartet, indtil det gaar over i det saakaldte "Biloculinler", som findes paa næsten alle Dybder, der er større end 1000 Favne.

Dette er et eiendommeligt, fint Sediment af en lysbrun til mørkbrun Farve og udmærker sig ved sin større eller mindre Rigdom paa smaa Foraminiferer. Fremtrædende for det blottede Øie er især deleshed Slægten *Biloculina* med sine smaa hvide Skaller, af Størrelse og Form som et Knappenaalshoved, spredte rundt omkring i Slammet. Dette er derfor af Zoologerne opkaldt efter disse smaa Dyr, der giver det et karakteristisk og let kjendeligt Udseende.

Vi skal senere tale om de øvrige i Leret forekommende Foraminiferer, som paa Grund af sit Udseende eller sin ringe Størrelse er mindre iøinefaldende end Biloculinerne, om de end i Antal er langt overveiende.

I den østlige Del af Nordhavet mellem Spidsbergen, Beeren Eiland, Norge og Novaja Semlja har vi fundet Bunden bedækket med et grøn-graat paa Dyrelevninger fattigt Ler. Dets grønlige Farve og øvrige karakteristiske Egenskaber er især deleshed udprægede i Bundprøverne fra de østligste Stationer. Zoologerne har kaldt dette Sediment

Atlantic Expedition, I will briefly state the results of the preliminary inspection and my own subsequent examination in so far as they bear on the distribution of the deposits over the bed of the ocean-tract explored.

To begin with, I must observe that for want of some other, more precise expression, I have chosen the term "clay" by which to designate all sedimentary deposits that, when free from moisture, still retain a certain degree of firmness and cohesive power. My description of the external characteristics of the samples refers chiefly to their appearance when dry, in which state they were submitted to analysis. I may observe here, that colour, mainly dependent on the degree of oxidation, constitutes the most salient distinctive feature of oceanic deposits.

In the shallower parts of the sea along the coasts of Norway and Spitzbergen we find the surface of the bottom covered with a more or less plastic clay, almost invariably grey in colour. The fineness of the substance composing it and the admixture of coarser particles, such as sand, pebbles, calcareous shells, varies very considerably in the numerous samples brought up from the sea-bed in those localities. This coastal clay is rarely met with farther down than 400—500 fathoms (700—900 metres).

At that depth the surface-layer of the bottom is generally found to consist of a brown clay, which announces transition to the true oceanic deposit. Where it first occurs, this brown clay, containing but few Foraminifera (transition clay), is often more or less sabulous and coarsely granulated; but farther down it gets finer and more homogeneous in substance, till it is ultimately merged into that sedimentary deposit to which our naturalists have given the name of "Biloculina clay," met with at almost all depths exceeding 1000 fathoms.

Biloculina clay is a fine deposit varying in colour from light to dark brown, and distinguished by a greater or less abundance of minute Foraminifera. Of those perceptible to the naked eye, by far the greater part belong to the genus *Biloculina,* with its minute white shells, resembling a pin's head in size and shape, dispersed throughout the sedimentary substance, to which these small animals give a characteristic and easily recognisable appearance; — whence the appropriate name suggested by the naturalists to the Expedition.

We shall afterwards speak of the other Foraminifera that occur in this clay, but which, owing either to their appearance or minute size, are less conspicuous than the *Biloculinæ,* though greatly exceeding those animals in number.

In the eastern tract of the Arctic ocean between Spitzbergen, Beeren Eiland, and Novaja Zemlja, we found the bottom covered with a greenish-grey clay, containing but few animal remains. Its green colour and other distinctive features are particularly prominent in the samples collected at the most easterly of the observing-stations.

Bestemmelsen af de smaa Stene, der blev fundne i Bundprøverne, er udført ganske overfladisk uden nøiere mikroskopiske Undersøgelser og derfor nødvendigvis maa betragtes med et vist Forbehold. Det vil saaledes forstaaes, at man ved Betragtning af disse smaa Brudstykker vanskelig skal kunne skjelne mellem de nærbeslægtede Bergarter (f. Ex. de forskjellige krystallinske Skifere), og endnu mindre lader det sig paa denne Maade afgjøre, hvor deres oprindelige Forekomststed har været. En nøiere Undersøgelse med Hensyn til det sidste Spørgsmaal vilde visselig være af Interesse, men paa Grund af det omstændelige Arbeide, som hertil kræves, har jeg foreløbig maattet sætte den tilside.

met with in the specimens of the bottom, I will state at once, that, having been roughly performed without the aid of the microscope, it does not pretend to more than comparative accuracy, and some reservation should accordingly be shown in receiving the results. It is no easy matter to distinguish at sight, when examining such small fragments, between different but closely resembling descriptions of rock (for instance the numerous crystalline schists), while the difficulty of thus determining their origin must be far greater, not to say insuperable. A closer examination with those objects in view would no doubt be well worth undertaking; but owing to the labour it would involve, I must await a more favourable opportunity for further investigations.

Bundprøver fra 1876.

Station 3. Nordlig Bredde 61° 5', Østlig Længde fra Greenwich 5° 15'. Sognefjorden. Dybde 618 Favne (1130 Meter). Bundtemperatur 6.6°. En liden Prøve af blaagraat og brungraat, sandholdigt Ler med nogle smaa Kvartskorn. Faa uorganiske Dyrelevninger.

Station 4. N. B. 61° 5', Ø. L. 5° 14'. 566 Fvn. (1035 M.). 6.6°. Graat, sandholdigt Ler med mange ganske smaa Stene (veiende indtil 0.5 Gr.), væsentlig bestaaende af Kvarts.

Station 5. N. B. 61° 6', Ø. L. 5° 12' 504 Fvn. (922 M.). 6.6°. Graat sandholdigt Ler.

Station 6. N. B. 61° 6', Ø. L. 5° 9'. 211 Fvn. (386 M.). 6.6°. Stenbund.

Station 7. N. B. 61° 6', Ø. L. 5° 11'. 206 Fvn. (377 M.). 6.6°. Stenbund.

Station 9. N. B. 61° 30', Ø. L. 3° 37'. 206 Fvn. (377 M.). 5.8°. Ensartet, lysgraat Ler. Ingen Stene. Mange uorganiske Dyrelevninger (især af Slægten *Uvigerina)*.

Station 10. N. B. 61° 41', Ø. L. 3° 19'. 220 Fvn. (402 M.). 6.0°. Fint, ensartet, brunliggraat Ler. Ingen Stene. Faa uorganiske Dyrelevninger.

Station 11. N. B. 61° 47', Ø. L. 3° 9'. 232 Fvn. (424 M.). 6.1°. Fint, graat Ler.

Samples of the Bottom (1876).

Station 3 (the Sognefjord). — Lat. 61° 5' N., long. 5° 15' E.; depth 618 fathoms (1130 metres); bottom-temperature 6.6°. A small sample of bluish-grey and brownish-grey sabulous clay containing granular fragments of quartz and a few inorganic animal remains.

Station 4. — Lat. 61° 5' N., long. 5° 14' E.; d. 566 fms. (1035 m.); b.-t. 6.6°. A grey sabulous clay containing numbers of very small pebbles, chiefly quartz, the biggest weighing 0.5^{gr}.

Station 5. — Lat. 61° 6' N., long. 5° 12' E.; d. 504 fms. (922 m.); b.-t. 6.6°. A grey, sabulous clay.

Station 6. — Lat. 61° 6' N., long. 5° 9' E.; d. 211 fms. (386 m.); b.-t. 6.6°. Bottom stony.

Station 7. — Lat. 61° 6' N., long. 5° 11' E.; d. 206 fms. (377 m.); b.-t. 6.6°. Bottom stony.

Station 9. — Lat. 61° 30' N., long. 3° 37' E.; d. 206 fms. (377 m.); b.-t. 5.8°. A uniform, light-grey clay containing numerous inorganic animal remains (particularly of the genus *Uvigerina).* No pebbles.

Station 10. — Lat. 61° 41' N., long. 3° 19' E.; d. 220 fms. (402 m.); b.-t. 6.0°. A uniformly fine, brownish-grey clay containing a few inorganic animal remains. No pebbles.

Station 11. — Lat. 61° 47' N., long. 3° 9' E.; d. 232 fms. (424 m.); b.-t. 6.1°. A fine, grey clay.

Station 12. N. B. 61° 53′, Ø. L. 3° 0′. 223 Fvn. (408 M.). 6.3°. Fint, graat Ler.

Station 13. N. B. 61° 58′, Ø. L. 2° 54′. 228 Fvn. (417 M.). 6.1°. Lysgraat, ensartet, finkornigt og fast Ler. Ingen Stene. Faa Kalkskaller.

Station 14. N. B. 62° 4′, Ø. L. 2° 45′. 226 Fvn. (413 M.). 6.1°. Graat, ensartet, grovkornigt Ler. Et lidet Stykke Jern, som muligens er afslidt Loddet. Ingen Stene. Mange Kalkskaller (*Uvigerina*).

Station 15. N. B. 62° 10′, Ø. L. 2° 36′. 221 Fvn. (404 M.). 6.1°. Graat, fint Ler.

Station 16. N. B. 62° 24′, Ø. L. 2° 17′. 221 Fvn. (404 M.). 4.6°. Stenbund.

Station 17. N. B. 62° 33′, Ø. L. 2° 4′. 288 Fvn. (527 M.). 2.4°. Stenbund.

Station 18. N. B. 62° 44′, Ø. L. 1° 48′. 412 Fvn. (753 M.). — 1.0°. Blanding af lysgraat Sandler og brunliggraat. fast og finkornigt Ler. I Bundprøven fandtes mange smaa Glimmerblade og afrundede Kvartskorn, men forøvrigt kun faa og ganske smaa Stene. Med Skraben optoges paa denne Station en stor, rund Sten, der viste sig at være en Breccie, en fin, graa Sandsten og en afrundet Marmorblok (0.25 M. lang og 0.15 M. bred). Efterat et Stykke var slaaet af den sidstnævnte Sten, flød der Vand ud af et Hul i dens Indre.

Station 19. N. B. 62° 23′, Ø. L. 2° 5.0′. 226 Fvn. (413 M.). 6.0°. Graat, sandholdigt Ler.

Station 20. N. B. 62° 16′, Ø. L. 3° 8′. 219 Fvn. (400 M.). 6.2°. Graat, grovkornigt og usammenhængende Ler tilligemed noget af en mørkere Slags. Ingen Stene. En Mængde Skaller af *Uvigerina*.

Station 21. N. B. 62° 14′, Ø. L. 3° 28′. 188 Fvn. (344 M.). 5.8°. Graat, sandholdigt Ler.

Station 24. N. B. 63° 10′, Ø. L. 5° 58′. 90 Fvn. (165 M.). 6.9°. Graat, sandholdigt Ler.

Station 26 a. N. B. 63° 10′, Ø. L. 5° 16′. 237 Fvn. (433 M.). 7.1°. Graat, sandholdigt Ler.

Station 26 b. N. B. 63° 7′, Ø. L. 5° 17′. 90 Fvn. (165 M.). 7.8°. Stenbund.

Station 27. N. B. 63° 6′, Ø. L. 5° 18′. 90 Fvn. (165 M.). 7.8°. Stenbund.

Station 12. — Lat. 61° 53′ N., long. 3° 0′ E.; d. 223 fms. (408 m.); b.-t. 6.3°. A fine, grey clay.

Station 13. — Lat. 61° 58′ N., long. 2° 54′ E.; d. 228 fms. (417 m.); b.-t. 6.1°. A firm, finely granulous, light-grey clay containing a few calcareous shells. No pebbles.

Station 14. — Lat. 62° 4′ N., long. 2° 45′ E.; d. 226 fms. (413 m.); b.-t. 6.1°. A grey, coarsely granulous clay containing numbers of calcareous shells (*Uvigerina*) and a particle of iron, possibly broken off one of the sinkers. No pebbles.

Station 15. — Lat. 62° 10′ N., long. 2° 36′ E.; d. 221 fms. (404 m.); b.-t. 6.1°. A fine, grey clay.

Station 16. — Lat. 62° 24′ N., long. 2° 17′ E.; d. 221 fms. (404 m.); b.-t. 4.6°. Bottom stony.

Station 17. — Lat. 62° 33′ N., long. 2° 4′ E.; d. 288 fms. (527 m.); b.-t. 2.4°. Bottom stony.

Station 18. — Lat. 62° 44′ N., long. 1° 48′ E.; d. 412 fms. (753 m.); b.-t. — 1.0°. A mixture of light-grey sabulous clay and brownish-grey, firm, and finely granulated clay containing numerous delicate laminæ of mica and globular granules of quartz, as also a few very small pebbles. The dredge brought up a big, round stone, which proved on inspection to be a breccie, together with a block of marble (0.25 m. long and 0.15 m. broad). On breaking off a piece of the latter, water was seen to well forth from an aperture in the side.

Station 19. — Lat. 62° 23′ N., long. 2° 5.0′ E.; d. 226 fms. (413 m.); b.-t. 6.0°. A grey, sabulous clay.

Station 20. — Lat. 62° 16′ N., long. 3° 8′ E.; d. 219 fms. (400 m.); b.-t. 6.2°. A grey coarsely granulous loose clay, along with a little of a darker tint containing countless shells of *Uvigerina*. No pebbles.

Station 21. — Lat. 62° 14′ N., long. 3° 28′ E.; d. 219 fms. (344 m.); b.-t. 5.8°. A grey, sabulous clay.

Station 24. — Lat. 63° 10′ N., long. 5° 58′ E.; d. 90 fms. (165 m.); b.-t. 6.9°. A grey, sabulous clay.

Station 26a. — Lat. 63° 10′ N., long. 5° 16′ E.; d. 237 fms. (433 m.); b.-t. 7.1°. A grey, sabulous clay.

Station 26b. — Lat. 63° 7′ N., long. 5° 17′ E.; d. 90 fms. (165 m.); b.-t. 7.8°. Bottom stony.

Station 27. — Lat. 63° 6′ N., long. 5° 18′ E.; d. 90 fms. (165 m.); b.-t. 7.8°. Bottom stony.

Station 28. N. B. 63° 10′, Ø. L. 5° 11′. 396 Fvn. (724 M.). — 0.5°. Graat, sandholdigt Ler.

Station 29. N. B. 63° 10′, Ø. L. 5° 7′. 396 Fvn. (724 M.). — 0.2°. Graat, sandholdigt Ler.

Station 30. N. B. 63° 10′, Ø. L. 5° 4′. 401 Fvn. (733 M.). — 0.4°. Fint, ensartet, lysgraat Ler. Ingen Stene. Faa Kalkskaller.

Station 31. N. B. 63° 10′, Ø. L. 5° 0′. 417 Fvn. (763 M.). — 0.9°. Graat, sandholdigt Ler.

Station 32. N. B. 63° 10′, Ø. L. 4° 51′. 430 Fvn. (786 M.). — 0.6°. Graat, fint Ler. Mange Stene i Bundprøven (veiende indtil 2.5 Gr.), bestaaende af Kvartsskifer, Gneis. I Skraben fandtes: Rød Sandsten, grøn Lerskifer, Granit, *Pimpsten* (5 × 5 × 5 Cm.) og endel ubestemmelige forvitrende Stene. Faa Kalkskaller.

Station 33. N. B. 63° 5′. Ø. L. 3° 0′. 525 Fvn. (960 M.). — 1.1°. Graat Ler.

Station 34. N. B. 63° 5′, Ø. L. 0° 53′. 587 Fvn. (1073 M.). — 1.0°. Graat, fint Ler (Slik).

Station 35. N. B. 63° 7′, V. L. 1° 26′. 1081 Fvn. (1977 M.). — 1.0°. Biloculinler.

Station 36. N. B. 62° 15′, V. L. 4° 34′. 148 Fvn. (271 M.). 7.9°. Stenbund.

Station 37. N. B. 62° 28′, V. L. 2° 29′. 690 Fvn. (1226 M.). — 1.1°. Brunt, sandholdigt Ler. Nogle smaa Stene. Mange fine Glimmerblade.

Station 38. N. B. 63° 1′, V. L. 3° 58′. 204 Fvn. (373 M.). 0.7°. Stenbund.

Station 40. N. B. 63° 22′, V. L. 5° 29′. 1215 Fvn. (2222 M.). — 1.2°. Ensartet Biloculinler med mange Biloculiner. I Bundprøven ingen Stene. I Skraben fandtes: Et Stykke af en tæt Gneis, Klumper og Knoller af forskjellig Form, Størrelse og Farve og nogle Pimpstenstykker.

Station 41. N. B. 63° 37′, V. L. 7° 10′. 697 Fvn. (1275 M.). — 1.0°. Fint, graat, ensartet Ler. Ingen Stene.

Station 42. N. B. 63° 2′, V. L. 10° 17′. 264 Fvn. (483 M.). 1.3°. Stenbund.

Station 43. N. B. 63° 11′, V. L. 13° 32′. 529 Fvn. (967 M.). 2.9°. Lerholdigt Sand.

Station 28. — Lat. 63° 10′ N., long. 5° 11′ E.; d. 396 fms. (724 m.); b.-t. — 0.5°. A grey, sabulous clay.

Station 29. — Lat. 63° 10′ N., long. 5° 7′ E.; d. 396 fms. (724 m.); b.-t. — 0.2°. A grey, sabulous clay.

Station 30. — Lat. 63° 10′ N., long. 5° 4′ E.; d. 401 fms. (733 m.); b.-t. — 0.4°. A fine, uniform, light-grey clay containing a few calcareous shells. No pebbles.

Station 31. — Lat. 63° 10′ N., long. 5° 0′ E.; d. 417 fms. (763 m.); b.-t. — 0.9°. A grey, sabulous clay.

Station 32. — Lat. 63° 10′ N., long. 4° 51′ E.; d. 430 fms. (786 m.); b.-t. — 0.6°. A fine, grey clay containing: — Numerous pebbles of silicious schist and gneiss; fragments of red sandstone, green argillaceous slate, granite, *pumice* (5 × 5 × 5 cm); divers indeterminable disintegrated particles of stone; a few calcareous shells.

Station 33. — Lat. 63° 5′ N., long. 3° 0′ E.; d. 525 fms. (960 m.); b.-t. — 1.1°. A grey clay.

Station 34. — Lat. 63° 5′ N., long. 0° 53′ E.; d. 587 fms. (1073 m); b.-t. — 1.0°. A grey mud.

Station 35. — Lat. 63° 7′ N., long. 1° 26′ W.; d. 1081 fms. (1977 m.); b.-t. — 1.0°. Biloculina clay.

Station 36. — Lat. 62° 15′ N., long. 4° 34′ W.; d. 148 fms. (271 m.); b.-t. 7.9°. Bottom stony.

Station 37. — Lat. 62° 28′ N., long. 2° 29′ W.; d. 690 fms. (1226 m.); b.-t. — 1.1°. A brown, sabulous clay containing a few small pebbles and numerous delicate micaceous laminæ.

Station 38. — Lat. 63° 1′ N., long. 3° 58′ W.; d. 204 fms. (373 m.); b.-t. 0.7°. Bottom stony.

Station 40. — Lat. 63° 22′ N., long. 5° 29′ W.; d. 1215 fms. (2222 m.); b.-t. - 1.2°. A uniform biloculina clay containing many *Biloculinæ*. No pebbles. The dredge brought up a fragment of compact gneiss, together with numerous nodules, or concretions, varying in form, magnitude, and colour, and a few pieces of pumice.

Station 41. — Lat. 63° 37′ N., long. 7° 10′ W.; d. 697 fms. (1275 m.); b.-t. — 1.0°. A fine, grey, uniform clay. No pebbles.

Station 42. — Lat. 63° 2.5′ N., long. 10° 17′ W.; d. 264 fms. (483 m.); b.-t. 1.3°. Bottom stony.

Station 43. — Lat. 63° 11′ N., long. 13° 32′ W. d. 529 fms. (967 m.); b.-t. 2.9°. Argillaceous sand.

Station 44. N. B. 63° 8'. V. L. 14° 0'. 844 Fvn. (1543 M.). 2.7°. Stenbund.

Station 45. N. B. 63° 28'. V. L. 12° 58'. 381 Fvn. (997 M.). 4.3°. Stenbund; blot en liden Prøve af brunt, lerholdigt Sand. Mange ganske smaa Stene: Kalkspath.

Station 46. N. Br. 63° 51'. V. L. 12° 5'. 257 Fvn. (470 M.). 3.9°. Sten og graat Ler.

Station 47. N. B. 64° 13.5'. V. L. 11° 14'. 190 Fvn. (347 M.). 6.0°. Stenbund.

Station 48. N. B. 64° 36'. V. L. 10° 22'. 299 Fvn. (547 M.). — 0.3°. Ensartet, mørkgraat, løst Ler. Nogle Stene i Bundprøven: Kvarts, Granit (veiende indtil 0.1 Gr.). Faa Kalkskaller.

Station 49. N. B. 65° 0'. V. L. 9° 25'. 437 Fvn. (799 M.). — 0.8°. Sandholdigt Ler.

Station 50. N. B. 65° 26'. V. L. 8° 24'. 571 Fvn. (1044 M.). — 0.9°. Mørkt, blaaliggraat Ler. Ingen Stene.

Station 51. N. B. 65° 53'. V. L. 7° 18'. 1163 Fvn. (2127 M.). — 1.1°. Biloculinler. Ingen Stene.

Station 52. N. B. 65° 47'. V. L. 3° 7'. 1861 Fvn. (3403 M.). — 1.2°. Biloculinler. Ingen Stene.

Station 53. N. B. 65° 13'. Ø. L. 0° 33'. 1539 Fvn. (2814 M.). — 1.3°. Biloculinler. Paa hver □Cm. af den tørrede Bundprøve 2—3 Biloculiner. Ingen Stene.

Station 54. N. B. 64° 47'. Ø. L. 4° 24'. 601 Fvn. (1099 M.). — 1.2°. Biloculinler. En Mængde Globigeriner. Ingen Stene.

Station 55. N. B. 64° 38'. Ø. L. 10° 22'. 93 Fvn. (170 M.). 7.2°. Stenbund.

Station 56. N. B. 64° 39'. Ø. L. 10° 11'. 178 Fvn. (326 M.). 7.2°. Graat, finkornigt, sandholdigt, løst Ler. Temmelig faa uorganiske Dyrelevninger.

Station 57. N. B. 64° 39'. Ø. L. 9° 59'. 161 Fvn. (284 M.). 7.0°. Blaaliggraat, fint, fast Ler. Mange Stene (veiende indtil 1.5 Gr.), bestaaende af krystallinske Skifere. Ingen Kalkskaller.

Station 58. N. B. 64° 39'. Ø. L. 9° 49'. 221 Fvn.

Station 44. — Lat. 63° 8' N., long. 14° 0' W.; d. 844 fms. (1543 m.); b.-t. 2.7°. Bottom stony.

Station 45. — Lat. 63° 28' N., long. 12° 58' W.; d. 381 fms. (997 m.); b.-t. 4.3°. Bottom stony; only a small sample of brown argillaceous sand. A great many pebbles of calcareous spar.

Station 46. — Lat. 63° 51' N., long. 12° 5' W.; d. 257 fms. (470 m.); b.-t. 3.9°. Pebbles and a grey clay.

Station 47. — Lat. 64° 13.5' N., long. 11° 14' W.; d. 190 fms. (347 m.); b.-t. 6.0°. Bottom stony.

Station 48. — Lat. 64° 36' N., long. 10° 22' W.; d. 299 fms. (547 m.); b.-t. — 0.3°. A dark-grey, porous clay containing a few pebbles of quartz and granite (the largest weighing 1 gr) and a few calcareous shells.

Station 49. — Lat. 65° 0' N., long. 9° 25' W.; d. 437 fms. (799 m.); b.-t. — 0.8°. A sabulous clay.

Station 50. — Lat. 65° 26' N., long. 8° 24' W.; d. 571 fms. (1044 m.); b.-t. — 0.9°. A dark, bluish-grey clay. No pebbles.

Station 51. — Lat. 65° 53' N., long. 7° 18' W.; d. 1163 fms. (2127 m.); b.-t. — 1.1°. Biloculina clay. No pebbles.

Station 52. — Lat. 65° 47' N., long. 3° 7' W.; d. 1861 fms. (3403 m.); b.-t. — 1.2°. Biloculina clay. No pebbles.

Station 53. — Lat. 65° 13' N., long. 0° 33' E.; d. 1539 fms. (2814 m.); b.-t. — 1.3°. Biloculina clay; to every □cm. of the dried sample 2 or 3 *Biloculinæ*. No pebbles.

Station 54. — Lat. 64° 47' N., long. 4° 24' E.; d. 601 fms. (1099 m.); b.-t. — 1.2°. Biloculina clay, containing a great many *Globigerinæ*. No pebbles.

Station 55. — Lat. 64° 38' N., long. 10° 22' E.; d. 93 fms. (170 m.); b.-t. 7.2°. Bottom stony.

Station 56. — Lat. 64° 39' N., long. 10° 11' E.; d. 178 fms. (326 m.); b.-t. 7.2°. A grey, porous, finely granulated, sandy clay containing but few inorganic animal remains.

Station 57. — Lat. 64° 39' N., long. 9° 59' E.; d. 161 fms. (284 m.); b.-t. 7.0°. A finely granulous, bluish-grey, compact clay containing numerous pebbles of crystalline schists, the largest weighing 1.5 gr. No calcareous shells.

Station 58. — Lat. 64° 39' N., long. 9° 49' E.; d.

(404 M.). 6.9°. Blaagraat, fint, fast Ler. Mange fine Glimmerblade, men forresten ingen Stene. Yderst faa uorganiske Dyrelevninger.

221 fms. (404 m.); b.-t. 6.9°. A fine, bluish-grey, compact clay containing numerous delicate laminæ of mica, but no pebbles, and very few inorganic animal remains.

Station 59. N. B. 64° 39′, Ø. L. 9° 38′. 167 Fvn. (305 M.). 6.9°. Graat, grovkornigt Ler. Nogle smaa Stene. Faa uorganiske Dyrelevninger.

Station 59. — Lat. 64° 39′ N., long. 9° 38′ E.; d. 167 fms. (305 m.); b.-t. 6.9°. A grey, coarsely granulated clay containing pebbles and a few inorganic animal remains.

Station 60. N. B. 64° 40′, Ø. L. 9° 30′. 118 Fvn. (216 M.). 7.0°. En liden Prøve af graat, uensartet, sandholdigt Ler. Mange Stene (veiende indtil 0.3 Gr.), bestaaende af rød Granit og krystallinske Skifere. Yderst faa Kalkskaller.

Station 60. — Lat. 64° 40′ N., long. 9° 30′ E.; d. 118 fms. (216 m.); b.-t. 7.0°. A small sample of grey, sabulous clay containing numerous pebbles (the largest weighing 0.3 gr.) of red granite and crystalline schists, and a very few calcareous shells.

Station 61. N. B. 64° 40′, Ø. L. 9° 19′. 118 Fvn. (216 M.). 7.0°. En liden Prøve af graat, fint, ensartet Ler. En liden Sten: glindsende Lerskifer (veiende 0.1 Gr.).

Station 61. — Lat. 64° 40′ N., long. 9° 19′ E.; d. 118 fms. (216 m.); b.-t. 7.0°. A little fine, grey, homogeneous clay containing a small pebble of glittering argillaceous state (weight 0.1 gr.).

Station 62. N. B. 64° 41′, Ø. L. 9° 10′. 108 Fvn. (198 M.). 7.0°. Blaaliggraat, fint Ler. Nogle meget smaa Stene.

Station 62. — Lat. 64° 41′ N., long. 9° 10′ E.; d. 108 fms. (198 m.); b.-t. 7.0°. A bluish-grey clay containing a few very small pebbles.

Station 63. N. B. 64° 41′, Ø. L. 9° 0′. 93 Fvn. (170 M.). 7.0°. Stenbund.

Station 63. — Lat. 64° 41′ N., long. 9° 0′ E.; d. 93 fms. (170 m.); b.-t. 7.0°. Bottom stony.

Station 64. N. B. 64° 42′, Ø. L. 8° 50′. 58 Fvn. (106 M.). 7.7°. Stenbund.

Station 64. — Lat. 64° 42′ N., long. 8° 50′ E.; d. 58 fms. (106 m.); b.-t. 7.7°. Bottom stony.

Station 65. N. B. 64° 42′, Ø. L. 8° 39′. 62 Fvn. (113 M.). 7.4°. Stenbund.

Station 65. — Lat. 64° 42′ N., long. 8° 39′ E.; d. 62 fms. (113 m.); b.-t. 7.4°. Bottom stony.

Station 66. N. B. 64° 43′, Ø. L. 8° 30′. 88 Fvn. (161 M.). 7.1°. En liden Prøve af graat, sandholdigt, fast Ler. Ingen Stene.

Station 66. — Lat. 64° 43′ N., long. 8° 30′ E.; d. 88 fms. (161 m.); b.-t. 7.1°. A small sample of grey, compact, sabulous clay. No pebbles.

Station 67. N. B. 64° 44′, Ø. L. 8° 19′. 119 Fvn. (218 M.). 6.9°. Blaagraat Ler. Mange smaa Stene (veiende indtil 0.3 Gr.), bestaaende af Kvarts, Kvartsit. Yderst faa Kalkskaller.

Station 67. — Lat. 64° 44′ N., long. 8° 19′ E.; d. 119 fms. (218 m.); b.-t. 6.9°. A bluish-grey clay containing many small pebbles (the largest weighing 3 gr.) of quartz, quartzite, and a very few calcareous shells.

Station 68. N. B. 64° 44′, Ø. L. 8° 9′. 132 Fvn. (241 M.). 6.9°. Graat, fint, ensartet Ler. Ingen Stene.

Station 68. — Lat. 64° 44′ N., long. 8° 9′ E.; d. 132 fms. (241 m.); b.-t. 6.9°. A fine, grey, homogeneous clay. No pebbles.

Station 69. N. B. 64° 45′, Ø. L. 8° 2′. 128 Fvn. (234 M.). 7.0°. Graat, meget sandholdigt Ler.

Station 69. — Lat. 64° 48′ N., long. 8° 2′ E.; d. 128 fms. (234 m.); b.-t. 7.0°. A grey, exceedingly sabulous clay.

Station 79.[1] N. B. 64° 48′, Ø. L. 6° 36′. 155 Fvn.

Station 79.[1] — Lat. 64° 48′ N., long. 6° 36′ E.; d.

[1] Fra de imellem 69 og 79 liggende Stationer er ingen Prøver medbragte hjem. Ifølge Loddejournalen fandtes paa alle disse Stationer et graat, sandholdigt Ler. Da disse Stationer følger meget tæt paa hinanden, har jeg fundet det unødvendigt at medtage dem i Fort.

[1] From the 8 Stations between 69 and 79 no samples were collected. According to the sounding-journal, a grey, sabulous clay occurred at each; and being all so near together, I have not included them in the List.

(283 M.). 6.9°. Graat, sandholdigt, fast Ler med noget af en løsere Slags. Mange Stene (veiende indtil 0.3 Gr.), bestaaende af Kvarts, Glimmer, forvitrende Horblende (?), Marmor, krystallinske Skifere. Mange Skaller af Slægten *Uvigerina.*

Station 80. N. B. 64° 48', Ø. L. 6° 26'. 144 Fvn. (263 M.). 6.8°. Graat, fint Ler.

Station 81. N. B. 64° 49', Ø. L. 6° 17'. 155 Fvn. (283 M.). 6.9°. Graat, fint Ler. Nogle Stene (veiende indtil 1 Gr.), bestaaende af Granit og krystallinske Skifere.

Station 84. N. B. 64° 49', Ø. L. 5° 49'. 221 Fvn. (404 M.). 6.5°. Graat, fint Ler.

Station 85. N. B. 64° 50', Ø. L. 5° 39'. 303 Fvn. (554 m.). 3.9°. Brunt Sandler.

Station 86. N. B. 64° 50', Ø. L. 5° 30'. 381 Fvn. (697 M.). — 1.0°. Graat Ler.

Station 87. N. B. 64° 2', Ø. L. 5° 35'. 498 Fvn. (911 M.). — 1.1°. Graat Ler.

Station 88. N. B. 64° 1', Ø. L. 5° 53'. 355 Fvn. (649 M.). 2.7°. Graat Ler.

Station 89. N. B. 64° 1', Ø. L. 6° 8'. 190 Fvn. (347 M.). 6.7°. Stenbund.

Station 90. N. B. 64° 1', Ø. L. 6° 21'. 205 Fvn. (375 M.). 6.6°. Graat, sandholdigt Ler.

Station 91. N. B. 64° 0', Ø. L. 6° 32'. 190 Fvn. (347 M.). 7.2°. Graat, fint Ler.

Station 92. N. B. 64° 0', Ø. L. 6° 42'. 178 Fvn. (326 M.). 7.2°. Graat, sandholdigt Ler. Nogle faa Stene. Mange fine Glimmerblade.

Station 93. N. B. 62° 41', Ø. L. 7° 8'. 158 Fvn. (289 M.). 6.4°. Romsdalsfjord. Løst, graat Ler.

155 fms. (283 m.); b.-t. 6.9°. A grey, sabulous clay, part compact and part comparatively porous, containing many small pebbles (the largest weighing 0.3 gr) of quartz, mica, disintegrated hornblende (?), marble, and crystalline schists, together with numbers of shells of the genus *Uvigerina.*

Station 80. — Lat. 64° 48' N., long. 6° 26' E.; d. 144 fms. (263 m.); b.-t. 6.8°. A finely granulous, grey clay.

Station 81. — Lat. 64° 49' N., long. 6° 17' E.; d. 155 fms. (283 m.); b.-t. 6.9°. A finely granulous, grey clay containing a few very small pebbles (the largest weighing 1 gr), of granite and crystalline schists.

Station 84. — Lat. 64° 49' N., long. 5° 49' E.; d. 221 fms. (404 m.); b.-t. 6.5°. A finely granulous, grey clay.

Station 85. — Lat. 64° 50' N., long. 5° 39' E.; d. 303 fms. (554 m.); b.-t. 3.9°. A brown, sabulous clay.

Station 86. — Lat. 64° 50' N., long. 5° 30' E.; d. 381 fms. (697 m.); b.-t. — 1.0°. A grey clay.

Station 87. — Lat. 64° 2' N., long. 5° 35' E.; d. 498 fms. (911 m.); b.-t. — 1.1°. A grey clay.

Station 88. — Lat. 64° 1' N., long. 5° 53' E.; d. 355 fms. (649 m.); b.-t. 2.7°. A grey clay.

Station 89. — Lat. 64° 1' N., long. 6° 8' E.; d. 190 fms. (347 m.); b.-t. 6.7°. Bottom stony.

Station 90. — Lat. 64° 1' N., long. 6° 21' E.; d. 205 fms. (375 m.); b.-t. 6.6°. A grey, sabulous clay.

Station 91. — Lat. 64° 0' N., long. 6° 32' E.; d. 190 fms. (347 m.); b.-t. 7.2°. A finely granulous, grey clay.

Station 92. — Lat. 64° 0' N., long. 6° 42' E.; d. 178 fms. (326 m.); b.-t. 7.2°. A grey, sabulous clay containing a few pebbles and many delicate laminæ of mica.

Station 93 (the Romsdal Fjord). — Lat. 62° 41' N., long. 7° 8' E.; d. 158 fms. (289 m.); b.-t. 6.4°. A grey, porous clay.

Bundprøver fra 1877.

Station 94. N. B. 59° 8'. Ø. L. 4° 38'. 145 Fvn. (265 M.). 5.0°. En liden Prøve af graat, grovkornigt Ler.

Station 95. N. B. 60° 42'. Ø. L. 4° 14'. 175 Fvn. (320 M.). 5.8°. Brungraat Ler med mange Brudstykker af Kalkskaller, Koraller og andre Dyrelevninger. Nogle smaa Kvartskorn.

Station 96. N. B. 66° 8', Ø. L. 3° 0'. 805 Fvn. (1472 M.). — 1.1°. Bundprøven bestod af to Lag. Øverst et brunt Ler, hvori der ikke kunde opdages Biloculiner og kun faa Globigeriner, men temmelig mange af Slægten *Lituola*. Man kan være i Tvivl om, hvorvidt dette Ler skal betragtes som Overgangsler eller Biloculinler. Jeg har imidlertid fundet det rettest at henregne det til det sidste (som dannende Begyndelsen til Biloculinleret). Det underliggende Lag af Bundprøven bestod af et graat, fint Ler. I Bundprøven ingen Stene. I Skraben fandtes 3 mindre Stene (den største 3 × 3 × 3 Cm.), bestaaende af blaa Kvarts, Sandsten, krystallinske Skifere.

Station 97. N. B. 66° 2', Ø. L. 4° 21'. 683 Fvn. (1249 M.). — 1.1°. To Lag i Bundprøven. Det øverste bestod af brunt Overgangsler, det underste af graat, fint Ler. Ingen Stene.

Station 98. N. B. 65° 56'. Ø. L. 5° 21'. 388 Fvn. (710 M.). — 1.0°. To Lag i Bundprøven. Det øverste brunt Overgangsler, det underste graat Ler. Ingen Stene.

Station 99. N. B. 65° 51', Ø. L. 6° 25'. 213 Fvn. (390 M.). 6.1°. Graabrunt, finkornigt, sandholdigt Ler. En liden Sten: Kvarts.

Station 100. N. B. 65° 43'. Ø. L. 7° 29'. 194 Fvn. (355 M.). 6.0°. Blanding af brunt Sandler og graat Ler. Mange Stene. Et lidet Stykke af en *Belemnit*.

Station 101. N. B. 65° 36'. Ø. L. 8° 32'. 223 Fvn. (408 M.). 6.0°. Graat, grovkornigt Sandler. Mange Stene (veiende indtil 1.5 Gr., bestaaende af Kvarts, krystallinske Skifere, Hornblende (?). I Skraben fandtes 6 smaa Stene: *Flint, Kridt*, Sandsten og krystallinske Skifere.

Station 102. N. B. 65° 32'. Ø. L. 9° 10'. 211 Fvn. (386 M.). 6.2°. Lysgraat Ler, tilblandet noget brunt Sandler. Ingen Stene.

Station 103. N. B. 65° 30'. Ø. L. 9° 37'. 193

Samples of the Bottom (1877).

Station 94. — Lat. 59° 8' N., long. 4° 38' E; d. 145 fms. (265 m.); b.-t. 5.0°. A small sample of grey, coarsely granulated clay.

Station 95. — Lat. 60° 42' N., long. 4° 14' E.; d. 175 fms. (320 m.); b.-t. 5.8°. A brownish-grey clay containing many fragments of calcareous shells, coral, and other animal remains; also a few quartz pebbles.

Station 96. — Lat. 66° 8' N., long. 3° 0' E.; d. 805 fms. (1472 m.); b.-t. — 1.1°. The sample consisted of two layers. In the upper — a brown clay — no *Biloculinæ* could be detected, and but very few *Globigerinæ*; it contained however a good many shells of the genus *Lituola*. It is difficult to decide whether this clay be a transition or a true Biloculina clay. Meanwhile, I have regarded it as the latter (as constituting the first bottom-layer of Biloculina clay). The under layer was a finely granulous, grey clay. No pebbles in this sample. The dredge brought up 3 pebbles (the largest 3 × 3 × 3 cm), consisting of blue quartz, sandstone, and crystalline schists.

Station 97. — Lat. 66° 2' N., long. 4° 21' E.; d. 683 fms. (1249 m.); b.-t. 1.1°. Two layers in this sample; the upper consisting of a brown transition clay, the under of a finely granulous, grey clay. No pebbles.

Station 98. — Lat. 65° 56' N., long. 5° 21' E.; d. 388 fms. (710 m.); b.-t. — 1.0°. Two layers; the upper a brown transition clay, the under a grey clay. No pebbles.

Station 99. — Lat. 65° 51' N., long. 6° 25' E.; d. 213 fms. (390 m.); b.-t. 6.1°. A greyish-brown, finely granulous, sandy clay containing a quartz pebble.

Station 100. — Lat. 65° 43' N., long. 7° 29' E.; d. 194 fms. (355 m.); b.-t. 6.0°. A mixture of brown sabulous clay and grey clay containing many pebbles and a small fragment of a *belemnite*.

Station 101. — Lat. 65° 36' N., long. 8° 32' E.; d. 223 fms. (408 m.); b.-t. 6.0°. A grey, coarsely granulated, sabulous clay containing a good many pebbles (the largest weighing 1.5 gr) of quartz, crystalline schists, hornblende (?). The dredge brought up 6 small stones, consisting of *flint, chalk*, sandstone, and crystalline schists.

Station 102. — Lat. 65° 32' N., long. 9° 10' E.; d. 211 fms. (386 m.); b.-t. 6.2°. A light-grey clay, slightly mixed with a brown, sabulous clay. No pebbles.

Station 103. — Lat. 65° 30' N., long. 9° 37' E.; d.

Station 115. N. B. 66° 20', Ø. L. 9° 41'. 132 Fvn. (241 M.). 6.2°. Graat Ler med talrige Glimmerblade. Mange Stene (veiende indtil 1 Gr.), bestaaende af Kvarts, Glimmerskifer o. fl.

Station 116. N. B. 66° 21', Ø. L. 9° 30'. 121 Fvn. (221 M.). 6.2°. Grønliggraat, grovkornigt Ler. Mange smaa Stene.

Station 117. N. B. 66° 23', Ø. L. 9° 20'. 141 Fvn. (258 M.). 6.2°. Brunliggraat, ensartet Ler (lig Stat. 111). Ingen Stene.

Station 118. N. B. 66° 26', Ø. L. 8° 59'. 141 Fvn. (258 M.). 6.2°. Graat, grovkornigt Ler. Mange Stene (veiende indtil 1 Gr.), bestaaende af Kvarts, Glimmerskifer, lys Granit.

Station 119. N. B. 66° 28', Ø. L. 8° 40'. 168 Fvn. (307 M.). 6.2°. Graat, ensartet Ler. Nogle smaa Stene (veiende indtil 0.1 Gr.), bestaaende af Kvarts og krystallinske Skifere.

Station 120. N. B. 66° 30', Ø. L. 8° 20'. 190 Fvn. (347 M.). 6.2°. Brunliggraat Ler. Nogle Stene (veiende indtil 3 Gr.), bestaaende af Kvarts, Gneis, Granit.

Station 121. N. B. 66° 33', Ø. L. 7° 59'. 192 Fvn. (351 M.). 4.8°. Graat Ler med mange Kalkskaller. Ingen Stene.

Station 122. N. B. 66° 36', Ø. L. 7° 40'. 201 Fvn. (368 M.). 4.9°. Graat, ensartet Ler. Mange Stene (veiende indtil 4 Gr.).

Station 123. N. B. 66° 39', Ø. L. 7° 19'. 246 Fvn. (450 M.). 5.6°. En liden Prøve af graat, uensartet, grovkornigt, klumpet Ler med mange Stene (veiende indtil 1.5 Gr.) bestaaende af: Kvarts, Granit og krystallinske Skifere.

Station 124. N. B. 66° 41', Ø. L. 6° 59'. 350 Fvn. (640 M.). — 0.9°. Bundprøven bestod af noget graat Ler med en Mængde Stene, væsentlig bestaaende af *Flint* og krystallinske Skifere. Skrabens Indhold bestod overveiende af Stene (den største 8 × 14 × 8 Cm.), der blev bestemt som: Finkornig rød Granit, grovkornig Ganggranit, hvid Granit med Ortit, Gneisgranit (med Hornblende, Plagioklas, Ortoklas), Hornblendeskifer, mørke krystallinske Skifere (med Kvarts, Glimmer, Granat), Glimmerskifer med Kis, Sandsten, grønlig Kvarts og grøn Feldspath. Disse Bergarter forekom i nævestore Stykker. Desuden fandtes en Mængde *Flint-* og *Kridstykker*, de sidste ialmindelighed runde (indtil 4 Cm. i Diameter).

Station 115. — Lat. 66° 20' N., long. 9° 41' E.; d. 132 fms. (241 m.); b.-t. 6.2°. A grey clay containing numerous laminæ of mica and many pebbles (the largest weighing 1^{gr}) of quartz, mica, schist, &c.

Station 116. — Lat. 66° 11' N., long. 9° 30' E.; d. 121 fms. (221 m.); b.-t. 6.2°. A greenish-grey, coarse clay containing many pebbles.

Station 117. — Lat. 66° 23' N., long. 9° 20' E.; d. 141 fms. (258 m.); b.-t. 6.2°. A brownish-grey, homogeneous clay resembling that brought up at Stat. 111. No pebbles.

Station 118. — Lat. 66° 26' N., long. 8° 59' E.; d. 141 fms. (258 m.); b.-t. 6.2°. A grey, coarse clay containing numerous pebbles (the largest weighing 1^{gr}) of quartz, mica, schist, granite.

Station 119. — Lat. 66° 28' N., long. 8° 40' E.; d. 168 fms. (307 m.); b.-t. 6.2°. A grey, homogeneous clay containing a few pebbles (the largest weighing 1^{gr}) of quartz and crystalline schists.

Station 120. — Lat. 66° 30' N., long. 8° 20' E.; d. 190 fms. (347 m.); b.-t. 6.2°. A brownish-grey clay containing a few pebbles (the largest weighing 3^{gr}) of quartz, gneiss, granite.

Station 121. — Lat. 66° 35' N., long. 7° 59' E.; d. 192 fms. (351 m.); b.-t. 4.8°. A grey clay containing many calcareous shells. No pebbles.

Station 122. — Lat. 66° 36' N., long. 7° 40' E.; d. 201 fms. (368 m.); b.-t. 4.9°. A grey homogeneous clay containing many pebbles (the largest weighing 4^{gr}).

Station 123. — Lat. 66° 39' N., long. 7° 19' E.; d. 246 fms. (450 m.); b.-t. 5.6°. A small sample of grey, coarse, lumpy clay containing many pebbles (the largest weighing 1.5^{gr}) of quartz, granite, and crystalline schists.

Station 124. — Lat. 66° 41' N., long. 6° 59' E.; d. 350 fms. (640 m.); b.-t. − 0.9°. A grey clay containing a great many pebbles, chiefly of *flint* and crystalline schists. The dredge brought up a freight consisting almost exclusively of stones and pebbles (the largest $8 \times 14 \times 8^{cm}$), determined as follows: — Finely granulated red granite, coarsely granulous vein-granite, white granite and ortite, gneiss-granite (containing hornblende, plagioklas, ortoklas), hornblende slate, dark crystalline schists (containing quartz, mica, granite), mica slate with pyrites, greenish quartz, and green feldspat. These fragments were as big as a man's fist. Moreover, the dredge-bag contained a great many pebbles of *flint* and *chalk*, most of the latter round, and the largest measuring 4^{cm} in diameter.

(1116 M.). — 1.1°. Brunt Overgangsler, meget uensartet i Farve. Mange Stene (veiende indtil 0.2 Gr.), bestaaende af Kvarts, Granit o. fl.

d. 610 fms. (1116 m.); b.-t. — 1.1°. A brown transition clay varying considerably in colour. It contained many pebbles (the largest weighing 0.2 gr) of quartz, granite, &c.

Station 137. N.B. 67° 24′, Ø.L. 8° 58′. 452 Fvn. (827 M.). — 1.0°. Blaaliggraat Ler. Mange og forholdsvis store Stene (veiende indtil 8 Gr.), bestaaende af Kvarts, Asbest, Glimmerskifer, Gneis med Granit. I Skraben fandtes ligeledes mange Stene, nogle med tydelige Skurstriber og glattede Overflader, store som Barnehoveder. Graa Gneis, hvid stribet Granit, rød stribet Granit, graa tæt Kvartsporfyr, finkornig Glimmerskifer, rød Kvarts.

Station 137. — Lat. 67° 24′ N., long. 8° 58′ E.; d. 452 fms. (827 m.); b.-t. — 1.0°. A bluish-grey clay containing many and comparatively large pebbles (weighing up to 8 gr) of quartz, asbestos, mica schist, gneiss with granite. The dredge brought up at this Station numerous pebbles and stones, consisting of grey gneiss, white lamellar granite, red lamellar granite, grey, compact quartz-porphyry, finely granulated mica schist, and red quartz. Some of these stones, as big as a child's head, had the surface polished with distinctly perceptible striæ.

Station 138. N.B. 67° 18′, Ø.L. 9° 9′. 184 Fvn. (336 M.). 6.0°. Grovt Sand og Sten.

Station 138. — Lat. 67° 18′ N., long. 9° 9′ E.; d. 184 fms. (336 m.); b.-t. 6.0°. Coarse sand and stones.

Station 139. N.B. 67° 14′, Ø.L. 9° 25′. 175 Fvn. (320 M.). 6.2°. Graa, grovkornigt Ler. Mange og forholdsvis store Stene (veiende indtil 1.5 Gr.), bestaaende af krystallinske Skifere, Feldspath o. fl.

Station 139. — Lat. 67° 14′ N., long. 9° 25′ E.; d. 175 fms. (320 m.); b.-t. 6.2°. A grey, coarse clay containing many pebbles (the largest weighing 1.5 gr) of crystalline schists, feldspat, &c.

Station 140. N.B. 67° 10′, Ø.L. 9° 42′. 197 Fvn. (360 M.). 6.2°. Graat Ler med mange Stene.

Station 140. — Lat. 67° 11′ N., long. 9° 42′ E.; d. 197 fms. (360 m.); b.-t. 6.2°. A grey clay containing many pebbles.

Station 141. N. B. 67° 6′, Ø. L. 9° 59′. 192 Fvn. (351 M.). 6.2°. Graat, grovkornigt Sandler. Mange smaa Stene (veiende indtil 0.5 Gr.), bestaaende af Kvarts, hvid Granit, krystallinske Skifere.

Station 141. — Lat. 67° 6′ N., long. 9° 59′ E.; d. 192 fms. (351 m.); b.-t. 6.2°. A grey, coarse, sandy clay containing many pebbles (weighing up to 0.5 gr) of quartz, white granite, crystalline schists.

Station 142. N.B. 67° 2′, Ø.L. 10° 17′. 178 Fvn. (326 M.). 6.2°. Grønliggraat Ler, gjennemvævet af Kiselspikuler af Svampe. Mange Stene (veiende indtil 2 Gr.), bestaaende af rød Granit og krystallinske Skifere.

Station 142. — Lat. 67° 2′ N., long. 10° 17′ E.; d. 178 fms. (326 m.); b.-t. 6.2°. A greenish-grey clay interwoven with the siliceous spicules of sponges, and containing many pebbles (weighing up to 2 gr) of red granite and crystalline schists.

Station 143. N. B. 66° 58′, Ø. L. 10° 33′. 189 Fvn. (346 M.). 6.2°. Graat, klumpet Ler med mange Stene (veiende indtil 3 Gr.), bestaaende af Kvarts og krystallinske Skifere.

Station 143. — Lat. 66° 58′ N., long. 10° 33′ E.; d. 189 fms. (346 m.); b.-t. 6.2°. A grey, lumpy clay containing many pebbles (the largest weighing 3 gr) of quartz and crystalline schists.

Station 144. N. B. 66° 53′, Ø. L. 10° 50′. 183 Fvn. (335 M.). 6.2°. Graat, grovkornigt, meget sandholdigt, usammenhængende Ler. Mange smaa Stene (veiende indtil 0.1 Gr.), bestaaende af Kvarts og krystallinske Skifere. Mange Kalkskaller (især Slægten *Discorbina).*

Station 144. — Lat. 66° 53′ N., long. 10° 50′ E.; d. 183 fms. (335 m.); b.-t. 6.2°. A grey, coarse, exceedingly sabulous, friable clay containing many pebbles (the largest weighing 0.1 gr) of quartz and crystalline schists; also a great many calcareous shells (in particular of the genus *Discorbina).*

Station 145. N.B. 66° 49′, Ø.L. 11° 7′. 198 Fvn. (362 M.). 5.9°. En liden Prøve af graat, grovkornigt Ler. Mange Stene (veiende indtil 0.5 Gr.), bestaaende af Kvarts, Gneis o. fl.

Station 145. — Lat. 66° 49′ N., long. 11° 7′ E.; d. 198 fms. (362 m.); b.-t. 5.9°. A small sample of grey, coarse clay containing many pebbles (weighing up to 0.5 gr) of quartz, gneiss, &c.

Station 146. N. B. 66° 45′, Ø. L. 11° 22′. 180

Station 146. — Lat. 66° 45′ N., long. 11° 22′ E.;

Fvn. (187 M.). 4.6°. Graat, grovkornigt Ler. En Sten: hvid, forvitrende Granit (veiende 3 Gr.).

Station 159. N. B. 67° 54', Ø. L. 10° 30'. 118 Fvn. (216 M.). 4.6°. Uensartet Blanding af Sand og graat Ler. Mange Stene (veiende indtil 1 Gr.), bestaaende af Granit, blød Lerskifer.

Station 160. N. B. 67° 58', Ø. L. 10° 11'. 280 Fvn. (512 M.). 5.9°. Mørkgraat, sandholdigt Ler. Nogle Stene: Lerskifere.

Station 161. N. B. 68° 3', Ø. L. 9° 53'. 592 Fvn. (1083 M.). — 1.1°. Graat Ler med noget fint Sand.

Station 162. N. B. 68° 23', Ø. L. 10° 20'. 795 Fvn. (1454 M.). — 1.2°. Brunt Overgangsler. Nogle Stene (veiende indtil 3 Gr.), bestaaende af Kvartsit, Gneis.

Station 163. N. B. 68° 22', Ø. L. 10° 30'. 690 Fvn. (1262 M.). — 1.2°. Brunt, grovkornigt, sandholdigt Overgangsler med noget graat Underler. Mange Stene, bestaaende af Kvarts, Feldspath, Granit, Gneis.

Station 164. N. B. 68° 21', Ø. L. 10° 40'. 457 Fvn. (836 M.). — 0.7°. Graat, sandholdig Ler. Mange Stene.

Station 165. N. B. 68° 46', Ø. L. 10° 51'. 1470 Fvn. (2688 M.). — 1.2°. Biloculinler.

Station 166. N. B. 68° 40', Ø. L. 11° 40'. 406 Fvn. (742 M.). 0.1°. Graat, grovkornigt Ler. Mange Stene (veiende indtil 4 Gr.), bestaaende af krystallinske Skifere.

Station 167. N. B. 68° 37', Ø. L. 12° 2'. 79 Fvn. (144 M.). 6.4°. Stenbund.

Station 168. N. B. 68° 39', Ø. L. 11° 51'. 444 Fvn. (812 M.). 2.3°. Brunt Overgangsler.

Station 169. N. B. 68° 36', Ø. L. 12° 53'. 72 Fvn. (132 M.). 5.4°. Stenbund.

Station 170. N. Br. 68° 32', Ø. L. 13° 18'. 67 Fvn. (123 M.). 5.2°. Stenbund.

Station 171. N. B. 69° 18', Ø. L. 14° 29'. 642 Fvn. (1174 M.). — 1.0°. To Lag i Bundprøven. Øverst brungraat Overgangsler, underst graat Ler. Ingen Stene.

d. 102 fms. (187 m.); b.-t. 4.6°. A grey, coarse clay containing a fragment of white disintegrated granite, weight 3 gr.

Station 159. — Lat. 67° 54' N., long. 10° 30' E.; d. 118 fms. (216 m.); b.-t. 4.6°. A mixture of sand and grey clay containing many pebbles (the largest weighing 1 gr) of granite and soft clay-slate.

Station 160. — Lat. 67° 58' N., long. 10° 11' E.; d. 280 fms. (512 m.); b.-t. 5.9°. A dark-grey, sabulous clay containing a few pebbles (clay-slate).

Station 161. — Lat. 68° 3' N., long. 9° 53' E.; d. 592 fms. (1083 m.); b.-t. — 1.1°. A grey clay mixed with fine sand.

Station 162. — Lat. 68° 23' N., long. 10° 20' E.; d. 795 fms. (1454 m.); b.-t. — 1.2°. A brown transition clay containing a few pebbles (the largest weighing 3 gr) of quartzite and gneiss.

Station 163. — Lat. 68° 22' N., long. 10° 30' E.; d. 690 fms. (1262 m.); b.-t. — 1.2°. A brown, coarse, sabulous transition clay mixed with a little grey clay; it contained many pebbles of quartz, feldspat, granite, gneiss.

Station 164. — Lat. 68° 21' N., long. 10° 40' E.; d. 457 fms. (836 m.); b.-t. — 0.7°. A grey, sabulous clay containing many pebbles.

Station 165. — Lat. 68° 46' N., long. 10° 51' E.; d. 1470 fms. (2688 m.); b.-t. — 1.2°. Biloculina clay.

Station 166. — Lat. 68° 40' N., long. 11° 40' E.; d. 406 fms. (742 m.); b.-t. 0.1°. A grey, coarse clay containing many pebbles (the largest weighing 4 gr) of crystalline schists.

Station 167. — Lat. 68° 37' N., long. 12° 2' E.; d. 79 fms. (144 m.); b.-t. 6.4°. Bottom stony.

Station 168. — Lat. 68° 39' N., long. 11° 51' E.; d. 444 fms. (812 m.); b.-t. 2.3°. A brown transition clay.

Station 169. — Lat. 68° 36' N., long. 12° 53' E.; d. 72 fms. (132 m.); b.-t. 5.4°. Bottom stony.

Station 170. — Lat. 68° 32' N., long. 13° 18' E.; d. 67 fms. (123 m.); b.-t. 5.2°. Bottom stony.

Station 171. — Lat. 69° 18' N., long. 14° 29' E.; d. 642 fms. (1174 m.); b.-t. — 1.0°. Two layers in this sample, — the upper layer a brownish-grey transition and the under a grey clay. No pebbles.

(2829 M.). — 1.3°. En liden Prøve af Biloculinler med noget lysgraat Ler. Ingen Stene.

Station 185. N. B. 70° 3'. Ø. L. 13° 37'. 1485 Fvn. (2716 M.). — 1.4°. En liden Prøve af Biloculinler. Ingen Stene.

Station 186. N. B. 69° 56'. Ø. L. 14° 18'. 1418 Fvn. (2593 M.). — 1.3°. En liden Prøve af Biloculinler.

Station 187. N. B. 69° 51'. Ø. L. 14° 41'. 1335 Fvn. (2441 M.). — 1.1°. To Lag i Bundprøven. Øverst brunt Overgangsler, underst graat Ler.

Station 188. N. B. 69° 43'. Ø. L. 15° 29'. 1185 (2167 M.). — 1.3°. Brunt Overgangsler, ikke ensartet i Farve.

Station 189. N. B. 69° 41'. Ø. L. 15° 42'. 860 Fvn. (1573 M.). — 1.1°. To Lag i Bundprøven, øverst brunt Overgangsler, underst graat Ler. Ingen Stene.

Station 190. N. B. 69° 41'. Ø. L. 15° 51'. 870 Fvn. (1591 M.). — 1.2°. Grovkornigt, sandholdigt, brunt Ler. Mange uorganiske Dyrelevninger. Mange smaa Stene (veiende indtil 0.2 Gr.), bestaaende af Kvarts, krystallinske Skifere.

Station 191. N. B. 69° 44'. Ø. L. 16° 26'. 249 Fvn. (455 M.). 5.2°. Uensartet, graat, klumpet Ler. Nogle Stene.

Station 192. N. B. 69° 46'. Ø. L. 16° 15'. 649 Fvn. (1187 M.). — 0.7°. Bundprøven bestaar væsentlig af uorganiske Dyrelevninger, sammenkittede ved brunt Ler. Ingen Stene.

Station 193. N. B. 69° 44'. Ø. L. 16° 54'. 46 Fvn. (84 M.). 5.5°. Stenbund.

Station 194. N. B. 69° 43'. Ø. L. 17° 16'. 29 Fvn. (53 M.). 5.4°. Stenbund.

Station 195. N. B. 70° 55'. Ø. L. 18° 38'. 107 Fvn. (196 M.). 5.1°. Brungraat Ler med mange Dyrelevninger (ligner Station 192). Mange Stene (veiende indtil 3 Gr.), bestaaende af Kvarts, Kvartsit, Gneis. I Skraben fandtes: Gabbro, Granit med blaa Kvarts, Kvartsskifer, Hornblendeskifer, Glimmerskifer.

Station 196. N. B. 71° 2'. Ø. L. 18° 3'. 122 Fvn. (223 M.). 5.1°. Brunt Sandler med noget graat Ler, gjennemvævet af Kiselspikuler Svampe. Ingen Stene.

1547 fms. (2829 m.); b.-t. — 1.3°. A small sample of Biloculina clay along with a little light-grey clay. No pebbles.

Station 185. — Lat. 70° 3' N., long. 13° 37' E.; d. 1485 fms. (2716 m.); b.-t. — 1.4°. A small sample of Biloculina clay. No pebbles.

Station 186. — Lat. 69° 56' N., long. 14° 18' E.; d. 1418 fms. (2593 m.); b.-t. — 1.3°. A small sample of Biloculina clay.

Station 187. — Lat. 69° 51' N., long. 14° 41' E.; d. 1335 fms. (2441 m.); b.-t. — 1.1°. Two layers, — the upper layer a brown transition the under a grey clay.

Station 188. — Lat. 69° 43' N., long. 15° 29' E.; d. 1185 fms. (2167 m.); b.-t. — 1.3°. A brown transition clay varying in colour.

Station 189. — Lat. 69° 41' N., long. 15° 42' E.; d. 860 fms. (1573 m.); b.-t. — 1.2°. Two layers, — the upper layer a brown transition clay, the under a grey clay. No pebbles.

Station 190. — Lat. 69° 41' N., long. 15° 51' E.; d. 870 fms. (1591 m.); b.-t. — 1.2°. A brown, coarse, sabulous clay containing numerous inorganic animal remains and many pebbles (the largest weighing 0.2gr) of quartz, crystalline schists.

Station 191. — Lat. 69° 44' N., long. 16° 26' E.; d. 249 fms. (455 m.); b.-t. 5.2°. A grey, lumpy, mixed clay. No pebbles.

Station 192. — Lat. 69° 46' N., long. 16° 15' E.; d. 649 fms. (1187 m.); b.-t. — 0.7°. This sample consisted almost exclusively of inorganic animal remains cemented together by means of a little brown clay. No pebbles.

Station 193. — Lat. 69° 44' N., long. 16° 54' E.; d. 46 fms. (84 m.); b.-t. 5.5°. Bottom stony.

Station 194. — Lat. 69° 43' N., long. 17° 16' E.; d. 29 fms. (53 m.); b.-t. 5.4°. Bottom stony.

Station 195. — Lat. 70° 55' N., long. 18° 38' E.; d. 107 fms. (196 m.); b.-t. 5.1°. A brownish-grey clay containing numerous inorganic animal remains, similar to those brought up at Station 192, and many pebbles (the largest weighing 3gr) of quartz, quartzite, gneiss. The dredge brought up fragments of gabbro, granite with blue quartz, quartz-schist, hornblende-schist, and mica-schist.

Station 196. — Lat. 71° 2' N., long. 18° 3' E.; d. 122 fms. (223 m.); b.-t. 5.1°. A brown, sabulous clay along with a little grey clay, interwoven with siliceous spicules of sponges. No pebbles.

Station 197. N. B. 71° 7', Ø. L. 17° 28'. 138 Fvn. (252 M.). 5.2°. Stenbund.

Station 198. N. B. 71° 13', Ø. L. 16° 52'. 226 Fvn. (413 M.). 3.8°. Stenbund.

Station 199. N. B. 71° 18', Ø. L. 16° 17'. 525 Fvn. (960 M.). — 0.6°. Stenbund.

Station 200. N. B. 71° 25', Ø. L. 15° 41'. 620 Fvn. (1134 M.). — 1.0°. Brunt, sandholdigt Overgangsler med et Underlag af mørkgraat Ler. Nogle smaa Stene, bestaaende af krystallinske Skifere.

Station 201. N. B. 71° 31', Ø. L. 15° 28'. 647 Fvn. (1183 M.). — 1.1°. Brunt, sandholdigt Overgangsler med noget blaagraat Underler. En Sten: Kvarts.

Station 202. N. B. 71° 31', Ø. L. 14° 40'. 803 Fvn. (1468 M.). — 1.1°. Ler (?).

Station 203. N. B. 71° 31', Ø. L. 13° 54'. 901 Fvn. (1648 M.). — 1.5°. En liden Prøve af graabrunt, fint Overgangsler, uensartet med Hensyn til Farven. Mange Stene (veiende indtil 3 Gr.), bestaaende af Kvarts, Gneis, Granit.

Station 204. N. B. 70° 57', Ø. L. 13° 34'. 1266 Fvn. (2315 M.). — 1.1°. Biloculinler med noget mørkere brunt Ler. Ingen Stene.

Station 205. N. B. 70° 51', Ø. L. 13° 3'. 1287 Fvn. (2354 M.). — 1.2°. Smukt Biloculinler. 1—2 Biloculiner paa hver □-Cm. af den tørrede Bundprøve. Mange af Slægten *Lituola* og *Globigerina*, enkelte af *Nonionina*. Ingen Stene. En Del af Bundprøven var stærkt oxyderet.

Station 206. N. B. 70° 45', Ø. L. 14° 36'. 1248 Fvn. (2282 M.). — 1.1°. Biloculinler. Faa Biloculiner og Globigeriner. Ingen Stene.

Station 207. N. B. 70° 33', Ø. L. 15° 50'. 1111 Fvn. (2032 M.). — 1.1°. Biloculinler. Nogle Stene (veiende indtil 0.2 Gr.), bestaaende af krystallinske Skifere.

Station 208. N. B. 70° 21', Ø. L. 16° 57'. 675 Fvn. (1234 M.). — 1.0°. Brunt porøst, sandholdigt Overgangsler. Mange Stene (veiende indtil 0.5 Gr.), bestaaende af Kvarts, krystallinske Skifere, Hornblende (?) og Feldspath.

Station 209. N. B. 70° 19', Ø. L. 17° 9'. 126 Fvn. (230 M.). 5.2°. Stenbund.

Station 197. — Lat. 71° 7' N., long. 17° 28' E.; d. 138 fms. (252 m.); b.-t. 5.2°. Bottom stony.

Station 198. — Lat. 71° 13' N., long. 16° 52' E.; d. 226 fms. (413 m.); b.-t. 3.8°. Bottom stony.

Station 199. — Lat. 71° 18' N., long. 16° 17' E.; d. 525 fms. (960 m.); b.-t. — 0.6°. Bottom stony.

Station 200. — Lat. 71° 25' N., long. 15° 41' E.; d. 620 fms. (1134 m.); b.-t. — 1.0°. A brown, sabulous transition clay with an under layer of dark-grey clay; it contained a few pebbles (crystalline schists).

Station 201. — Lat. 71° 31' N., long. 15° 28' E.; d. 647 fms. (1183 m.); b.-t. — 1.1°. A brown, sabulous transition clay with a thin under layer of blue clay; it contained a small fragment of quartz.

Station 202. — Lat. 71° 31' N., long. 14° 40' E.; d. 803 fms. (1468 m.); b.-t. — 1.1°. Clay (?).

Station 203. — Lat. 71° 31' N., long. 13° 54' E.; d. 901 fms. (1648 m.); b.-t. — 1.5°. A small sample of a fine, greyish-brown transition clay, varying in colour; it contained many pebbles (weighing up to 3 gr) of quartz, gneiss, granite.

Station 204. — Lat. 70° 57' N., long. 13° 34' E.; d. 1266 fms. (2315 m.); b.-t. — 1.1°. Biloculina clay along with a little dark-brown clay. No pebbles.

Station 205. — Lat. 70° 51' N., long. 13° 3' E.; d. 1287 fms. (2354 m.); b.-t. — 1.2°. A fine sample of Biloculina clay (1 or 2 *Biloculinæ* to every □ cm. of the dried sample) containing many shells of the genera *Lituola* and *Globigerina*, and a few of the genus *Nonionina*. No pebbles. A portion of this sample had undergone oxidation.

Station 206. — Lat. 70° 45' N., long. 14° 36' E.; d. 1248 fms. (2282 m.); b.-t. — 1.1° Biloculina clay containing but few *Biloculinæ* and *Globigerinæ*. No pebbles.

Station 207. — Lat. 70° 33' N., long. 15° 50' E.; d. 1111 fms. (2032 m.); b.-t. — 1.1°. Biloculina clay containing a few pebbles (weighing up to 0.2 gr) of crystalline schists.

Station 208. — Lat. 70° 21' N., long. 16° 57' E.; d. 675 fms. (1234 m.); b.-t. — 1.0°. A brown, porous, sandy transition clay containing many pebbles (weighing up to 0.5 gr), of quartz, crystalline schists, hornblende (?), and feldspar.

Station 209. — Lat. 70° 19' N., long. 17° 9' E.; d. 126 fms. (230 m.); b.-t. 5.2°. Bottom stony.

Station 210. N. B. 70° 17′, Ø. L. 17° 20′. 137 Fvn. (251 M.). 6.0°. Stenbund.

Station 211. N. B. 70° 15′, Ø. L. 17° 31′. 129 Fvn. (236 M.). 6.0°. En liden Prøve af grøngraat Ler, gjennemvævet af Kiselspikuler af Svampe. Mange Skalbrudstykker og hele Skaller af kalkafsondrende Dyr. Ingen Stene.

Station 212. N. B. 70° 12′, Ø. L. 17° 41′. 142 Fvn. (260 M.). 5.8°. Sand og Ler (?).

Station 213. N. B. 70° 23′, Ø. L. 2° 30′. 1760 Fvn. (3219 M.). — 1.2°. Kun Spor af Biloculinler, overveiende *graat fint,* meget plastisk Ler (underliggende Lag).

Station 214. N. B. 70° 39′, Ø. L. 0° 0′. 1750 Fvn. (3200 M.). — 1.2°. To Lag i Bundprøven. Øverst Biloculinler, underst *graat* fint, meget plastisk Ler. En Sten: krystallinsk Skifer (veiende 0.3 Gr.).

Station 215. N. B. 70° 53′, V. L. 2° 0′. 1665 Fvn. (3045 M.) — 1.2°. Biloculinler med graat Underler.

Station 216. N. B. 70° 58′, Ø. L. 3° 40′. 1231 Fvn. (2251 M.). — 1.3°. Biloculinler med graat Underler.

Station 217. N. B. 71° 0′, V. L. 5° 9′. 829 Fvn. (1516 M.). — 1.3°. Sandholdigt Biloculinler med nogle faa Biloculiner. Nogle Stene.

Station 218. N. B. 71° 1′, V. L. 6° 0′. 968 Fvn. (1770 M.). — 1.3°. Eiendommeligt, uensartet, sandholdigt Biloculinler med nogle faa Biloculiner, men temmelig mange Globigeriner. Et lidet Stykke Stenkul (?).

Station 219. N. B. 71° 2′, V. L. 6° 51′. 796 Fvn. (1456 M.). — 1.2°. Biloculinler med mange Foraminiferer, væsentlig Globigeriner.

Station 220. N. B. 71° 2′, V. L. 7° 26′. 1275 Fvn. (2332 M.). — 1.5°. Stenbund (?).

Station 221. N. B. 71° 2′, V. L. 7° 35′. 1060 Fvn. (1938 M.). — 1.3°. Stenbund.

Station 222. N. B. 71° 2′, V. L. 7° 46′. 654 Fvn. (1196 M.). — 1.0°. Stenbund.

Station 222 a. N. B. 71° 3′, V. L. 7° 54′. 144 Fvn. (263 M.). Graasort vulkansk Sandler.

Station 222 b. N. B. 71° 0′, V. L. 8° 29′. 20

Station 210. — Lat. 70° 17′ N., long. 17° 20′ E.; d. 137 fms. (251 m.); b.-t. 6.0°. Bottom stony.

Station 211. — Lat. 70° 15′ N., long. 17° 31′ E.; d. 129 fms. (236 m.); b.-t. 6.0°. A small sample of greenish-grey clay interwoven with the siliceous spicules of sponges, and containing besides many fragments of calcareous shells and whole shells of lime-secreting animals. No pebbles.

Station 212. — Lat. 70° 12′ N., long. 17° 41′ E.; d. 142 fms. (260 m.); b.-t. 5.8°. Sand and clay (?).

Station 213. — Lat. 70° 23′ N., long. 2° 30′ E.; d. 1760 fms. (3219 m.); b.-t. — 1.2°. A very little Biloculina clay, the remainder of the sample consisting of a *fine, grey,* exceedingly plastic clay (the under layer).

Station 214. — Lat. 70° 39′ N., long. 0° 0′; d. 1750 fms. (3200 m.); b.-t. — 1.2°. Two layers; the upper Biloculina clay, the under a fine, *grey,* exceedingly plastic clay; the sample contained a small fragment of crystalline schist, weighing 0.3 gr.

Station 215. — Lat. 70° 53′ N., long. 2° 0′ W.; d. 1665 fms. (3045 m.); b.-t. — 1.2°. Biloculina clay with a grey under layer.

Station 216. — Lat. 70° 58′ N., long. 3° 40′ W.; d. 1231 fms. (2251 m.); b.-t. — 1.3°. Biloculina clay with a grey under layer.

Station 217. — Lat. 71° 0′ N., long. 5° 9′ W.; d. 829 fms. (1516 m.); b.-t. — 1.3°. A brown, sabulous clay containing a few *Biloculinæ* and a few pebbles.

Station 218. — Lat. 71° 1′ N., long. 6° 0′ W.; d. 968 fms. (1770 m.); b.-t. — 1.3°. A peculiar, heterogeneous, brown, sandy clay containing a few *Biloculinæ* and a good many *Globigerinæ;* also a small fragment of coal (?).

Station 219. — Lat. 71° 2′ N., long. 6° 51′ W.; d. 796 fms. (1456 m.); b.-t. — 1.2°. Biloculina clay containing many Foraminifera, chiefly *Globigerinæ.*

Station 220. — Lat. 71° 2′ N., long. 7° 26′ W.; d. 1275 fms. (2332 m.); b.-t. — 1.5°. Bottom stony.

Station 221. — Lat. 71° 2′ N., long. 7° 35′ W.; d. 1060 fms. (1938 m.); b.-t. — 1.3°. Bottom stony.

Station 222. — Lat. 71° 2′ N., long. 7° 46′ W.; d. 654 fms. (1196 m.); b.-t. — 1.0°. Bottom stony.

Station 222 a. — Lat. 71° 3′ N., long. 7° 54′ W.; d. 144 fms. (263 m.). A greyish-black, volcanic, sabulous clay.

Station 222 b. — Lat. 71° 0′ N., long. 8° 29′ W.;

Fvn. (37 M.). 1.2°. Graasort vulkansk Sandler.

Station 223. N. B. 70° 54', V. L. 8° 24'. 70 Fvn. (128 M.). — 0.6°. Graasort, løst Ler. Nogle Stene, væsentlig bestaaende af basaltisk Lava.

Station 224. N. B. 70° 51', V. L. 8° 20'. 95 Fvn. (174 M.). — 0.6°. Graasort, vulkansk Sand og Sandler. Faa Stene. Mange smaa Brudstykker af lysgrønt Olivin.

Station 225. N. B. 70° 58', V. L. 8° 4'. 195 Fvn. (357 M.). — 0.6°. Graasort vulkansk Sandler (lig det foregaaende). Ingen Stene.

Station 226. N. B. 70° 59', V. L. 7° 51'. 340 Fvn. (622 M.). — 0.6°. Graasort, vulkansk Sandler.

Station 227. N. B. 71° 13', V. L. 7° 33'. 1040 Fvn. (1902 M.). — 1.5°. Mørkbrunt Ler.

Station 228. N. B. 71° 12', V. L. 8° 9'. 933 Fvn. (1706 M.). — 1.5°. Stenbund.

Station 229. N. B. 71° 12', V. L. 8° 55'. 732 Fvn. (1339 M.). — 1.3°. Mørkbrunt Ler. Ingen Biloculiner og faa andre Foraminiferer. Nogle smaa Stene, væsentlig bestaaende af vulkanske Slakker med Olivin.

Station 230. N. B. 71° 16', V. L. 9° 10'. 854 Fvn. (1562 M.). — 1.3°. Mørkbrunt Ler. Et Par Stene (veiende indtil 1.5 Gr.), bestaaende af basaltisk Lava.

Station 231. N. B. 71° 21', V. L. 9° 23'. 1032 Fvn. (1887 M.). — 1.3°. Haardt, lysbrunt, uensartet Ler. Faa Biloculiner, nogle Globigeriner. Ingen af Slægten *Lituola*. Flere smaa Stene (veiende indtil 0.3 Gr.), bestaaende af Kvarts, Sandsten (?).

Station 232. N. B. 71° 10', V. L. 8° 48'. 780 Fvn. (1426 M.). — 1.3°. Blanding af brunt og graat Ler. Ingen Stene.

Station 233. N. B. 71° 8', V. L. 8° 46'. 580 Fvn. (1061 M.). — 1.4°. Gulbrunt Ler.

Station 234. N. B. 71° 6', V. L. 8° 38'. 259 Fvn. (474 M.). — 1.0°. Graasort, tung Sandler. Flere Stene (veiende indtil 0.3 Gr.), bestaaende af vulkanske Slakker, porøs, basaltisk Lava.

Station 235. N. B. 70° 59', V. L. 8° 55'. 98 Fvn. (179 M.). 0.0°. Stenbund.

d. 20 fms. (37 m.); b.-t. 1.2°. A greyish-black, volcanic sabulous, clay.

Station 223. — Lat. 70° 54' N., long. 8° 24' W.; d. 70 fms. (128 m.); b.-t. — 0.6°. A greyish-black, friable clay containing a few pebbles, chiefly of basaltic lava.

Station 224. — Lat. 70° 51' N., long. 8° 20' W.; d. 95 fms. (174 m.); b.-t. — 0.6°. Greyish-black, volcanic sand and sandy clay containing many small fragments of olivine, but very few other pebbles.

Station 225. — Lat. 70° 58' N., long. 8° 4' W.; d. 195 fms. (357 m.); b.-t. — 0.6°. A greyish-black, volcanic sabulous clay similar to the foregoing. No pebbles.

Station 226. — Lat. 70° 59' N., long. 7° 51' W.; d. 340 fms. (622 m.); b.-t. — 0.6°. A greyish-black, volcanic, sabulous clay.

Station 227. — Lat. 71° 13' N., long. 7° 33' W.; d. 1040 fms. (1902 m.); b.-t. — 1.5°. A dark-brown clay.

Station 228. — Lat. 71° 12' N., long. 8° 9' W.; d. 933 fms. (1706 m.); b.-t. — 1.5°. Bottom stony.

Station 229. — Lat. 71° 12' N., long. 8° 55' W.; d. 732 fms. (1339 m.); b.-t. — 1.3°. A dark-brown clay containing a very few Foraminifera (no *Biloculinæ)* and a few pebbles, chiefly of scoriæ with olivine.

Station 230. — Lat. 71° 16' N., long. 9° 10' W.; d. 854 fms. (1562 m.); b.-t. — 1.3°. A dark-brown clay containing one or two small fragments (weighing 1.5gr) of basaltic lava.

Station 231. — Lat. 71° 21' N., long. 9° 23' W.; d. 1032 fms. (1887 m.); b.-t. — 1.3°. A hard, light-brown, heterogeneous clay containing: — Very few *Biloculinæ;* a few *Globigerinæ* (none of the genus *Lituola);* divers pebbles (the largest weighing 0.3gr) of quartz, sandstone (?).

Station 232. — Lat. 71° 10' N., long. 8° 48' W.; d. 780 fms. (1426 m.); b.-t. — 1.3°. A mixture of brown and grey clay. No pebbles.

Station 233. — Lat. 71° 8' N., long. 8° 46' W.; d. 580 fms. (1061 m.); b.-t. — 1.4°. A yellowish-brown clay.

Station 234. — Lat. 71° 6' N., long. 8° 38' W.; d. 259 fms. (474 m.); b.-t. — 1.0°. A greyish-black, heavy, sabulous clay containing divers pebbles (the largest weighing 0.3gr), of scoriæ, and porous, basaltic lava.

Station 235. — Lat. 70° 59' N., long. 8° 55' W.; d. 98 fms. (179 m.); b.-t. 0.0°. Bottom stony.

Station 236. N. B. 70° 58', V. L. 9° 2'. 156 Fvn. (285 M.). Graasort vulkansk Sandler (lig 234). Ingen Stene.

Station 237. N. B. 70° 41', V. L. 10° 10'. 263 Fvn. (481 M.). — 0.3°. Brunt, løst, sandholdigt Ler. Mange Stene, bestaaende af Olivin, Lava og smukke Krystaller af Augit. I Skraben fandtes en Mængde Stene: Kvarts, Glimmerskifer med Lav paa Overfladen, sort Lava med Feldspath-Krystaller, do. do. med smaa, runde, tomme Blærerum (denne Sten var rund), grøn kloritisk Skifer med Kispunkter, Lava med Olivin, Anorthit (?), Augit og Hornblende; sort, tæt Lava med Punkter af Magnetjern, brun, tæt Lava, Mandelsten, brun Lava med Rustpunkter, grovkornig Granit og krystallinske Skifere. Desforuden fandtes i Skraben mange smukke Krystaller af Augit, Hornblende og Olivin.

Station 238. N. B. 70° 13', V. L. 10° 54'. 845 Fvn. (1545 M.). — 1.1°. Biloculinler (?).

Station 239. N. B. 69° 35', V. L. 11° 13'. 1050 Fvn. (1920 M.). — 1.0°. Lysbrunt Biloculinler.

Station 240. N. B. 69° 2', V. L. 11° 26'. 1004 Fvn. (1836 M.). — 1.1°. Lysbrunt Biloculinler med en Mængde forskjellige Foraminiferer, væsentlig Globigeriner. Et Par ganske smaa Stene, bestaaende af mørk Kvarts (veiende indtil 0.1 Gr.).

Station 241. N. B. 68° 41', V. L. 10° 54'. 1119 Fvn. (2046 M.). — 1.4°. Smukt, lysbrunt Biloculinler (lig det foregaaende) med en Mængde Foraminiferer. En ganske liden Sten (veiende omtrent 0.02 Gr.).

Station 242. N. B. 68° 36', V. L. 8° 40'. 1033 Fvn. (1889 M.). — 1.3°. Biloculinler, noget grovkornigt, faa Biloculiner, men mange Globigeriner. Ingen af Slægten *Lituola*, mange *Nonionina*.

Station 243. N. B. 68° 32', V. L. 6° 26'. 1385 Fvn. (2533 M.). — 1.3°. Biloculinler med mange Foraminiferer.

Station 244. N. B. 68° 28', V. L. 4° 17'. 1951 Fvn. (3568 M.). — 1.3°. Biloculinler, lig det foregaaende. Af Foraminiferer fandtes væsentlig Globigeriner.

Station 245. N. B. 68° 21', V. L. 2° 5'. 2005 Fvn. (3667 M.). — 1.4°. I Biloculinler fra denne Station fandtes en Lagdannelse; det øverste Lag af Bundprøven var et yderst fint, plastisk, brunt Ler uden Foraminiferer. Det underste Lag bestod af lysere brunt, porøst

Station 236. — Lat. 70° 58' N., long. 9° 2' W.; d. 156 fms. (285 m.). A greyish-black, volcanic, sabulous clay similar to that brought up at Station 234. No pebbles.

Station 237. — Lat. 70° 41' N., long. 10° 10' W.; 263 fms. (481 m.); b.-t. — 0.3°. A brown, sabulous, friable clay containing many particles of olivine and beautiful crystals of augite. The dredge brought up great numbers of pebbles, as quartz, mica-schist coated over with lichen black lava with crystals of feldspar, black lava with small round, empty vesicles (this fragment was globular in form), green chloritic schist with pyritic granules, lava with olivine, anorthite (?), augite, hornblende, black compact lava with grains of magnetite, brown compact lava, amygdaloid, brown lava with specks of rust, coarse-grained granite, and crystalline schists. Moreover, the dredge contained many beautiful crystals of augite, hornblende, and olivine.

Station 238. — Lat. 70° 13' N., long. 10° 54' W.; d. 845 fms. (1545 m.); b.-t. — 1.1°. Biloculina clay (?).

Station 239. — Lat. 69° 35' N., long. 11° 13' W.; d. 1050 fms. (1920 m.); b.-t. — 1.0°. A light-brown Biloculina clay.

Station 240. — Lat. 69° 2' N., long. 11° 26' W.; d. 1044 fms. (1836 m.); b.-t. — 1.1°. A light-brown Biloculina clay containing great numbers of Foraminifera, chiefly *Globigerinæ*, and one or two fine particles of quartz, the largest weighing 0.1 gr.

Station 241. — Lat. 68° 41' N., long. 10° 54' W.; d. 1119 fms. (2046 m.); b.-t. — 1.4°. A fine sample of light-brown Biloculina clay, similar to the foregoing, containing great numbers of Foraminifera, and a small pebble, weighing about 0.02 gr.

Station 242. — Lat. 68° 36' N., long. 8° 40' W.; d. 1033 fms. (1889 m.); b.-t. — 1.3°. A somewhat coarsely granulated Biloculina clay containing many *Globigerinæ* and *Nonioninæ*, but very few *Biloculinæ*; the genus *Lituola* was not represented.

Station 243. — Lat. 68° 32' N., long. 6° 26' W.; d. 1385 fms. (2533 m.); b.-t. — 1.3°. Biloculina clay containing many Foraminifera.

Station 244. — Lat. 68° 28' N., long. 4° 17' W.; d. 1951 fms. (3568 m.); b.-t. — 1.3°. Biloculina clay containing many Foraminifera, chiefly *Globigerinæ*.

Station 245. — Lat. 68° 21' N., long. 2° 5' W.; d. 2005 fms. (3667 m.); b.-t. — 1.4°. The sample of Biloculina clay that came up at this Station, was in two layers; the upper a brown, exceedingly fine and plastic clay, without any Foraminifera, the under a lighter brown, porous clay

Ler med en Mængde Globigeriner, Biloculiner og andre Foraminiferer.

Station 246. N. B. 68° 14′, Ø. L. 0° 6′. 1592 Fvn. (2911 M.). — 1.3°. Biloculinler med to Lag, ligesom det foregaaende. Ingen Stene.

Station 247. N. B. 68° 5′, Ø. L. 2° 24′. 1120 Fvn. (2048 M.). — 1.2°. Biloculinler.

Station 248. N. B. 67° 56′, Ø. L. 4° 11′. 778 Fvn. (1423 M.). — 1.4°. Biloculinler.

Station 249. N. B. 68° 12′, Ø. L. 6° 35′. 1063 Fvn. (1944 M.). — 1.3°. Biloculinler med noget mørkere brunt Ler.

Station 250. N. B. 68° 10′, Ø. L. 9° 20′. 1150 Fvn. (2103 M.). — 1.4°. To Lag i Bundprøven, øverst lysbrunt Overgangsler, underst graat Ler. Ingen Biloculiner. Mange Stene, væsentlig bestaaende af krystallinske Skifere.

Station 251. N. B. 68° 6′, Ø. L. 9° 44′. 634 Fvn. (1159 M.). — 1.3°. To Lag i Bundprøven. Øverst sandholdigt, brunt Overgangsler med nogle Biloculiner og Globigeriner. Mange Stene (veiende indtil 1 Gr.), bestaaende af Gneis, Feldspath, Kvarts.

Station 253, Vestfjorden. 263 Fvn. (481 M.). 3.2°. Graagrønligt, fast og ensartet Ler. Ingen Stene.

Station 254. N. B. 67° 27′, Ø. L. 13° 25′. 143 Fvn. (262 M.). 5.8°. Ensartet, graat Ler. Flere Stene.

Bundprøver fra 1878.

Station 255. N. B. 68° 12′, Ø. L. 15° 40′. 341 Fvn. (624 M.). 6.5°. Blaagraat Ler med en Mængde uorganiske Dyrelevninger. Ingen Stene.

Station 256. N. B. 70° 8′, Ø. L. 23° 4′. 225 Fvn. (411 M.). 4.0°. Graagrønt, ensartet Ler. Faa Stene (veiende indtil 0.2 Gr.), bestaaende af Kvarts og krystallinske Skifere.

Station 257. N. B. 70° 4′, Ø. L. 23° 2′. 160

containing great numbers of *Globigerinæ*, *Biloculinæ*, and other Foraminifera.

Station 246. — Lat. 68° 14′ N., long. 0° 6′ E.; d. 1592 fms. (2911 m.); b.-t. — 1.3°. A sample of Biloculina clay in two layers, like the foregoing. No pebbles.

Station 247. — Lat. 68° 5′ N., long. 2° 4′ E.; d. 1120 fms. (2048 m.); b.-t. — 1.2°. Biloculina clay.

Station 248. — Lat. 67° 56′ N., long. 4° 11′ E.; d. 778 fms. (1423 m.); b.-t. — 1.4°. Biloculina clay.

Station 249. — Lat. 68° 12′ N., long. 6° 35′ E.; d. 1063 fms. (1944 m.); b.-t. — 1.3°. Biloculina clay along with a little of a darker tint.

Station 250. — Lat. 68° 10′ N., long. 9° 20′ E.; d. 1150 fms. (2103 m.); b.-t. — 1.4°. Two layers, — the upper a light-brown transition clay, the under a grey clay, containing together many pebbles, chiefly of crystalline schists. No *Biloculinæ*.

Station 251. — Lat. 68° 6′ N., long. 9° 44′ E.; d. 634 fms. (1159 m.); b.-t. — 1.3°. Two layers, — the upper a brown, sabulous transition clay containing a few *Biloculinæ* and *Globigerinæ* and many pebbles (the largest weighing 1 gr) of gneiss, feldspar, quartz.

Station 253 (Vestfjorden). — D. 263 fms. (481 m.); b.-t. 3.2°. A firm, greyish-green, homogeneous clay. No pebbles.

Station 254. — Lat. 67° 27′ N., long. 13° 25′ E.; d. 143 fms. (262 m.); b.-t. 5.8°. A grey, homogeneous clay containing divers pebbles.

Samples of the Bottom (1878).

Station 255. — Lat. 68° 12′ N., long. 15° 40′ E.; d. 341 fms. (624 m.); b.-t. 6.5°. A grey clay containing great numbers of inorganic animal remains. No pebbles.

Station 256. — Lat. 70° 8′ N., long. 23° 4′ E.; d. 225 fms. (411 m.); b.-t. 4.0°. A greyish-green homogeneous clay containing a few pebbles (the largest weighing 0.2 gr) of quartz and crystalline schists.

Station 257. — Lat. 70° 4′ N., long. 23° 2′ E.;

Fvn. (293 M.). 3.9°. Ensartet, graat Ler. Ingen Stene.

Station 258. N. B. 70° 13′, Ø. L. 23° 3′. 230 Fvn. (421 M.). 4.0°. Grøngraat Ler.

Station 259. N. B. 70° 49′, Ø. L. 25° 59′. 80 Fvn. (146 M.). 4.1°. En liden Prøve af grøngraat Ler, lignende Rhabdamminaleret. En Mængde Dyrelevninger: Koraller, Skaller af Slægten *Astarte* og Rør af Annelider *(Spiochetopterus)*. Mange Stene, bestaaende af Kvartsit, Glimmerskifer med Granat, Gneis, Granit.

Station 260. N. B. 70° 55′, Ø. L. 26° 11′. 127 Fvn. (232 M.). 3.5°. Ler.

Station 261. N. B. 70° 47′, Ø. L. 28° 30′. 127 Fvn. (232 M.). 2.8°. Ensartet, lysgraat Ler. Ingen Stene.

Station 262. N. B. 70° 36′, Ø. L. 32° 35′. 148 Fvn. (271 M.). 1.9°. Brunt, ensartet Sandler. Ingen Stene.

Station 263. N. B. 70° 44′, Ø. L. 34° 14′. 121 Fvn. (221 M.). 1.9°. Grønliggraat, temmelig fast Ler. Ingen Stene.

Station 264. N. B. 70° 56′, Ø. L. 35° 37′. 86 Fvn. (157 M.). 1.9°. Løst, grøngraat Rhabdamminaler med noget fastere, graat Underler.

Station 266. N. B. 71° 27′, Ø. L. 35° 39′. 130 Fvn. (238 M.). 0.6°. Øverst i Bundprøven et tyndt Lag af grøngraat Rhabdamminaler, under graat, fastere Ler. Mange Annelider *(Spiochetopterus)*.

Station 267. N. B. 71° 42′, Ø. L. 37° 1′. 148 Fvn. (271 M.). — 1.4°. Løst Rhabdamminaler med noget graat Underler. Mange Annelider og Skaller af Slægten *Astarte*. Ingen Stene.

Station 268. N. B. 71° 36′, Ø. L. 36° 18′. 130 Fvn. (238 M.). — 1.0°. Løst Rhabdamminaler.

Station 269. N. B. 72° 11′, Ø. L. 36° 40′. 138 Fvn. (252 M.). — 1.2°. Rhabdamminaler (ligner 264). Mange Annelider. Smaa Stykker af Stenkul. Ingen Stene.

Station 270. N. B. 72° 27′, Ø. L. 35° 1′. 136 Fvn. (249 M.). 0.0°. Ensartet, grøngraat Rhabdamminaler. Mange Annelider. Ingen Stene.

d. 160 fms. (293 m.); b.-t. 3.9°. A grey, homogeneous clay. No pebbles.

Station 258. — Lat. 70° 13′ N., long. 23° 3′ E.; d. 230 fms. (421 m.); b.-t. 4.0°. A greenish-grey clay.

Station 259. — Lat. 70° 49′ N., long. 25° 59′ E.; d. 80 fms. (146 m.); b.-t. 4.1°. A small sample of green, glistening Rhabdammina clay containing great numbers of animal remains, as coral, shells of the genus *Astarte* and tubes of Annelids *(Spiochetopterus)*; also many pebbles, consisting of quartzite, mica schist with garnets, gneiss, granite.

Station 260. — Lat. 70° 55′ N., long. 26° 11′ E.; d. 127 fms. (232 m.); b.-t. 3.5°. Bottom clay.

Station 261. — Lat. 70° 47′ N., long. 28° 30′ E.; d. 127 fms. (232 m.); b.-t. 2.8°. A light-grey, homogeneous clay. No pebbles.

Station 262. — Lat. 70° 36′ N., long. 32° 35′ E.; d. 148 fms. (271 m.); b.-t. 1.9°. A brown, homogeneous, sandy clay. No pebbles.

Station 263. — Lat. 70° 44′ N., long. 34° 14′ E.; d. 121 fms. (221 m.); b.-t. 1.9°. A greenish-grey, comparatively firm clay. No pebbles.

Station 264. — Lat. 70° 56′ N., long. 35° 37′ E.; d. 86 fms. (157 m.); b.-t. 1.9°. A friable, greenish-grey Rhabdammina clay, with a thin under layer of a somewhat firmer grey clay.

Station 266. — Lat. 71° 27′ N., long. 35° 39′ E.; d. 130 fms. (238 m.); b.-t. 0.6°. Two layers, — the upper consisting of a little greenish-grey Rhabdammina clay, the under of a firmer grey clay; this sample contained many Annelids *(Spiochetopterus)*.

Station 267. — Lat. 71° 42′ N., long. 37° 1′ E.; d. 148 fms. (271 m.); b.-t. — 1.4°. A friable Rhabdammina clay on a thin layer of grey clay, containing many Annelids and shells of the genus *Astarte*. No pebbles.

Station 268. — Lat. 71° 36′ N., long. 36° 18′ E.; d. 130 fms. (238 m.); b.-t. — 1.0°. A friable Rhabdammina clay.

Station 269. — Lat. 72° 11′ N., long. 36° 40′ E.; d. 138 fms. (252 m); b.-t. — 1.2°. Rhabdammina clay (similar to the sample brought up at Station 264) containing small fragments of coal, but no pebbles.

Station 270. — Lat. 72° 27′ N., long. 15° 1′ E.; d. 136 fms. (249 m.); b.-t. 0.0°. A greyish-green, homogeneous Rhabdammina clay containing many Annelids. No pebbles.

Station 271. N. B. 72° 38′, Ø. L. 33° 50′. 160 Fvn. (293 M.). 0.7°. En liden Prøve af ensartet, grøngraat Ler. Mange Annelider. Ingen Stene.

Station 272. N. B. 73° 11′, Ø. L. 33° 3′. 113 Fvn. (207 M.). 1.5°. Grøngraat Rhabdamminaler med noget fastere graat Underler. Nogle Stene (veiende indtil 1.0 Gr.), bestaaende af mørk Kalksten.

Station 273. N. B. 73° 25′, Ø. L. 31° 30′. 197 Fvn. (360 M.). 2.2°. Grønliggraat Rhabdammina-Ler. Mange Skaller *(Astarte)*. Mange ganske smaa Stene, hovedsagelig bestaaende af Kvarts.

Station 274. N. B. 73° 46′, Ø. L. 31° 16′. 182 Fvn. (333 M.). 0.0°. Graagrønt Rhabdammina-Ler. Mange Stene (veiende indtil 0.5 Gr.), bestaaende af Sandsten.

Station 275. N. B. 74° 8′, Ø. L. 31° 12′. 147 Fvn. (269 M.). — 0.4°. Grøngraat Rhabdammina-Ler. Mange Stene (veiende indtil 3 Gr.), bestaaende af oxyderet og forvitrende Sandsten, nogle smaa Stykker af Stenkul. I Skraben fandtes: Haard sort Lerskifer, Stenkul, graa Sandsten, Granit, Lerboller, Amfibolit, kornig Kalksten og Kvartsit.

Station 276. N. B. 74° 5′, Ø. L. 27° 39′. 220 Fvn. (402 M.). 0.9°. Graat Ler. Ingen Stene.

Station 277. N. B. 74° 3′, Ø. L. 25° 43′. 225 Fvn. (411 M.). 1.0°. Grøngraat Rhabdammina-Ler. Nogle Stene.

Station 278. N. B. 74° 1′, Ø. L. 22° 27′. 230 Fvn. (421 M.). 0.9°. Grøngraat Rhabdammina-Ler.

Station 279. N. B. 74° 15′, Ø. L. 20° 48′. 79 Fvn. (144 M.). 1.0°. Grøngraat, uensartet Rhabdammina-Ler. Mange Koraller og Skjæl. Nogle Stene (veiende indtil 0.5 Gr.), bestaaende af Kvarts, Sandsten.

Station 280. N. B. 74° 10′, Ø. L. 18° 51′. 35 Fvn. (64 M.). 1.1° Bundprøven bestod hovedsagelig af Muslingskaller med noget grøngraat Ler.

Station 281. N. B. 74° 3′, Ø. L. 17° 18′. 115 Fvn. (210 M.). 2.2°. Brunt Sandler og graat Ler. Nogle Stene (veiende indtil 0.1 Gr.), bestaaende af Kvarts, Sandsten.

Station 282. N. B. 73° 53′, Ø. L. 15° 36′. 457 Fvn. (836 M.). — 0.9°. Grøngraat Ler.

Station 271. — Lat. 72° 38′ N., long. 33° 50′ E.; d. 160 fms. (293 m.); b.-t. 0.7°. A small sample of greenish-grey, homogeneous clay containing numerous Annelids. No pebbles.

Station 272. — Lat. 73° 11′ N., long. 33° 3′ E.; d. 113 fms. (207 m.); b.-t. 1.5°. A greenish-grey Rhabdammina clay on a thin layer of firmer grey clay, containing a few pebbles (the largest weighing 1.0 gr) of dark limestone.

Station 273. — Lat. 73° 25′ N., long. 31° 30′ E.; d. 197 fms. (360 m.); b.-t. 2.2°. A greenish-grey clay containing many calcareous shells *(Astarte)* and many exceedingly fine pebbles, chiefly quartz.

Station 274. — Lat. 73° 46′ N., long. 31° 16′ E.; d. 182 fms. (333 m.); b.-t. 0.0°. A greyish-green Rhabdammina clay containing many pebbles (the largest weighing 0.5 gr), exclusively sandstone.

Station 275. — Lat. 74° 8′ N., long. 31° 12′ E.; d. 147 fms. (269 m.); b.-t. — 0.4°. A greyish-green Rhabdammina clay containing many pebbles (the largest weighing 3 gr) of oxidized and disintegrated sandstone, and a few small fragments of coal. The dredge brought up fragments of a hard, black argillaceous schist, of coal, grey sandstone, granite, amphibolite, granulated limestone, quartzite, and lumps of clay.

Station 276. — Lat. 74° 5′ N., long. 27° 39′ E.; d. 220 fms. (402 m.); b.-t. 0.9°. A grey clay. No pebbles.

Station 277. — Lat. 74° 3′ N., long. 25° 43′ E.; d. 225 fms. (411 m.); b.-t. 1.0°. A greenish-grey clay. No pebbles.

Station 278. — Lat. 74° 1′ N., long. 22° 27′ E.; d. 230 fms. (421 m.); b.-t. 0.9°. A greenish-grey clay.

Station 279. — Lat. 74° 15′ N., long. 20° 48′ E.; 79 fms. (144 m.); b.-t. 1.0°. A greenish-grey clay containing many shells and fragments of coral; likewise a few pebbles (the largest weighing 0.5 gr) of quartz, sandstone.

Station 280. — Lat. 74° 10′ N., long. 18° 51′ E.; d. 35 fms. (64 m.); b.-t. 1.1°. This sample consisted chiefly of muscle-shells along with a little greenish-grey clay.

Station 281. — Lat. 74° 3′ N., long. 17° 18′ E.; d. 115 fms. (210 m.); b.-t. 2.2°. A brown, sabulous clay and a grey clay containing a few pebbles (the largest weighing 0.1 gr) of quartz, sandstone.

Station 282. — Lat. 73° 53′ N., long. 15° 36′ E.; d. 457 fms. (836 m.); b.-t. — 0.9°. A greenish-grey clay.

Station 283. N. B. 73° 47', Ø. L. 14° 21'. 767 Fvn. (1403 M.). — 1.4°. Brunt Overgangsler med lidt graat Underler. Ingen Stene.

Station 284. N. B. 73° 1', Ø. L. 12° 58'. 800 Fvn. (1463 M.). — 1.3°. Brunt Overgangsler med lidt mørkgraat Underler. Ingen Stene.

Station 285. N. B. 73° 6', Ø. L. 11° 56'. 1024 Fvn. (1873 M.). — 1.3°. Brunt Overgangsler med graat Underler. I det graa Underler to Stene: Sandsten (veiende indtil 4 Gr.).

Station 286. N. B. 72° 57', Ø. L. 14° 32'. 447 Fvn. (817 M.). — 0.8°. Graat Ler med mange Stene (veiende indtil 2 Gr.), bestaaende af Kvarts, Feldspath, Sandsten. I Skraben fandtes mange tilrundede Stene: Hornblendeskifer, graa Kalksten, Gneisgranit, Gneis, Labradorsten.

Station 287. N. B. 72° 52', Ø. L. 15° 19'. 249 Fvn. (455 M.). 2.9°. Grønliggraat Ler med lidt brunt Sandler. Mange Stene (veiende indtil 4 Gr.), bestaaende af Sandsten, Granit, Kvartsit.

Station 288. N. B. 72° 46', Ø. L. 17° 50'. 215 Fvn. (393 M.). 2.4°. Ensartet, brunt Overgangsler med noget graat Underler. Nogle faa Stene (veiende indtil 0.5 Gr.), bestaaende af mørke krystallinske Skifere.

Station 289. N. B. 72° 41', Ø. L. 20° 18'. 219 Fvn. (400 M.). 2.0°. Grøngraat, haardt Ler. Ingen Stene.

Station 290. N. B. 72° 27', Ø. L. 20° 51'. 191 Fvn. (349 M.). 3.5°. Ensartet, brunt Sandler med lidt mørkgraat Ler. Faa og ganske smaa Stene (veiende indtil 0.3 Gr.), bestaaende af krystallinske Skifere.

Station 291. N. B. 71° 54', Ø. L. 21° 57'. 194 Fvn. (355 M.). 3.0°. Graat, sandholdigt Ler. Ingen Stene.

Station 292. N. B. 71° 20', Ø. L. 22° 59'. 216 Fvn. (395 M.). 3.7°. Brunliggraat Ler. Ingen synlige Foraminiferer.

Station 293. N. B. 71° 7', Ø. L. 21° 11'. 95 Fvn. (174 M.). 5.1°. Sandholdigt, graat (?) Ler.

Station 294. N. B. 71° 35', Ø. L. 15° 11'. 637 Fvn. (1165 M.). — 1.2°. Ensartet, brungraat Overgangsler. Ingen Stene. Enkelte Globigeriner. Nogle af Slægten *Lituola*.

Station 283. — Lat. 73° 47' N., long. 14° 21' E.; d. 767 fms. (1403 m.); b.-t. — 1.4°. A brown transition clay on a thin layer of grey clay. No pebbles.

Station 284. — Lat. 73° 1' N., long. 12° 58' E.; d. 800 fms. (1463 m.); b.-t. — 1.3°. A brown transition clay on a thin layer of dark-grey clay. No pebbles.

Station 285. — Lat. 73° 6' N., long. 11° 56' E.; d. 1024 fms. (1873 m.); b.-t. — 1.3°. A brown transition clay on a layer of grey clay, the latter containing two pebbles of sandstone (the largest weighing 4gr).

Station 286. — Lat. 72° 57' N., long. 14° 32' E.; d. 447 fms. (817 m.); b.-t. — 0.8°. A grey clay containing many pebbles (the largest weighing 2gr) of quartz, feldspar, sandstone. The dredge brought up numerous pebbles of hornblende schist, grey limestone, gneiss-granite, gneiss, labrador-stone.

Station 287. — Lat. 72° 52' N., long. 15° 19' E.; d. 249 fms. (455 m.); b.-t. 2.9°. A greenish-grey clay along with a little brown, sabulous clay containing together many pebbles (the largest weighing 4gr) of sandstone, granite, quartzite.

Station 288. — Lat. 72° 46' N., long. 17° 50' E.; d. 215 fms. (393 m.); b.-t. 2.4°. A brown, homogeneous, transition clay on a thin layer of grey clay, containing a few pebbles (the largest weighing 0.5gr of dark crystalline schists.

Station 289. — Lat. 72° 41' N., long. 20° 18' E.; d. 219 fms. (400 m.); b.-t. 2.0°. A hard, greenish-grey clay. No pebbles.

Station 290. — Lat. 72° 27' N., long. 20° 51' E.; d. 191 fms. (349 m.); b.-t. 3.5°. A brown, homogeneous, sandy clay along with a little dark-grey clay, containing together a few pebbles (the largest weighing 0.3gr) of crystalline schists.

Station 291. — Lat. 71° 54' N., long. 21° 57' E.; d. 194 fms. (355 m.); b.-t. 3.0°. A grey, sabulous clay. No pebbles.

Station 292. — Lat. 71° 20' N., long. 22° 59' E.; d. 216 fms. (395 m.); b.-t. 3.7°. A brownish-grey clay, in which no Foraminifera could be detected.

Station 293. — Lat. 71° 7' N., long. 21° 11' E.; d. 95 fms. (174 m.); b.-t. 5.1°. Sabulous clay.

Station 294. — Lat. 71° 35' N., long. 15° 11' E.; d. 637 fms. (1165 m.); b.-t. — 1.2°. A brownish-grey, homogeneous clay containing a few *Globigerinæ* and *Lituola*. No pebbles.

Station 295. N. B. 71° 59′, Ø. L. 11° 40′. 1110 Fvn. (2030 M.). — 1.3°. Ensartet Biloculinler. Ingen Stene.

Station 296. N. B. 72° 15′, Ø. L. 8° 9′. 1440 Fvn. (2633 M.). — 1.4°. Biloculinler. 5—6 Biloculiner paa hver □-Tomme af den tørrede Bundprøve. Ingen Stene.

Station 297. N. B. 72° 36′, Ø. L. 5° 12′. 1280 Fvn. (2341 M.). — 1.4°. Biloculinler. Faa Foraminiferer. Nogle Stene (veiende indtil 0.8 Gr.), bestaaende af Kvarts, Gneis, Grønsten, Sandsten, Feldspath, Glimmer.

Station 298. N. B. 72° 52′, Ø. L. 1° 51′. 1500 Fvn. (2743 M.). — 1.5°. Ensartet Biloculinler. Omtrent 2 Biloculiner paa hver □-Tomme af den tørrede Bundprøve. Nogle Stene, bestaaende af Kvarts og krystallinske Skifere.

Station 299. N. B. 73° 10′, V. L. 2° 14′. 1366 Fvn. (2498 M.). — 1.6°. Biloculinler. En Sten: Granit.

Station 301. N. B. 74° 1′, V. L. 1° 20′. 1684 Fvn. (3080 M.). — 1.6°. Biloculinler med noget graat underliggende Ler. Nogle Stene (veiende indtil 0.3 Gr.), bestaaende af Kvarts, krystallinske Skifere, Granit. Nogle smaa Fliser af raaddent Træ.

Station 302. N. B. 75° 16′, V. L. 0° 54′. 1985 Fvn. (3630 M.). — 1.7°. En yderst liden Prøve af Biloculinler. En Sten: Lerskifer (veiende 0.5 Gr.).

Station 303. N. B. 75° 12′, Ø. L. 3° 2′. 1200 Fvn. (2195 M.). — 1.6°. Ensartet Biloculinler. 3—4 Biloculiner paa hver □-Tomme af den tørrede Bundprøve. Nogle Stene (veiende indtil 0.3 Gr.), hovedsagelig bestaaende af rød Granit.

Station 304. N. B. 75° 3′, Ø. L. 4° 51′. 1735 Fvn. (3173 M.). — 1.5°. Bundprøven mangler.

Station 305. N. B. 75° 1′, Ø. L. 7° 56′. 1590 Fvn. (2908 M.). — 1.5°. Biloculinler med noget mørkegraat Underler. I Biloculinleret fandtes to Lag — i Lighed med Bundprøven fra Station 245. Nogle Stene: Lerskifere.

Station 306. N. B. 75° 0′, Ø. L. 10° 27′. 1334 Fvn. (2440 M.). — 1.3°. Biloculinler med mange Biloculiner. En Sten: Lerskifer (veiende 1.5 Gr.), omgivet af rødt, stærkt oxyderet Ler.

Station 307. N. B. 74° 58′, Ø. L. 12° 10′. 1216 Fvn. (2224 M.). — 1.4°. Biloculinler.

Station 295. — Lat. 71° 59′ N., long. 11° 40′ E.; d. 1110 fms. (2030 m.); b.-t. — 1.3°. A homogeneous Biloculina clay. No pebbles.

Station 296. — Lat. 72° 15′ N., long. 8° 9′ E.; d. 1440 fms. (2633 m.); b.-t. — 1.4°. Biloculina clay with 5 or 6 *Biloculinæ* to every square inch of the dried sample. No pebbles.

Station 297. — Lat. 72° 36′ N., long. 5° 12′ E.; d. 1280 fms. (2341 m.); b.-t. — 1.4°. Biloculina clay containing a few Foraminifera and divers pebbles (the largest weighing 8^gr^) of quartz, gneiss, sandstone, feldspar, mica.

Station 298. — Lat. 72° 52′ N., long. 1° 51′ E.; d. 1500 fms. (2743 m.); b.-t. — 1.5°. A homogeneous Biloculina clay with about 2 *Biloculinæ* to every square inch of the dried sample, and containing besides a few pebbles of quartz and crystalline schist.

Station 299. — Lat. 73° 10′ N., long. 2° 14′ W.; d. 1366 fms. (2498 m.); b.-t. — 1.6°. Biloculina clay containing a pebble of granite.

Station 301. — Lat. 74° 1′ N., long. 1° 20′ W.; d. 1684 fms. (3080 m.); b.-t. — 1.6°. Biloculina clay on a thin layer of grey clay, containing a few pebbles (the largest weighing 0.3^gr^) of quartz, crystalline schist, granite, and a few splinters of rotten wood.

Station 302. — Lat. 75° 16′ N., long. 0° 54′ W.; d. 1985 fms. (3630 m.); b.-t. — 1.7°. A very small sample of Biloculina clay containing a pebble of argillaceous slate (weighing 0.5^gr^).

Station 303. — Lat. 75° 12′ N., long. 3° 2′ E.; d. 1200 fms. (2195 m.); b.-t. — 1.6°. A homogeneous Biloculina clay with 3 or 4 *Biloculinæ* to every square inch of the dried sample, and containing besides a few pebbles (the largest weighing 0.3^gr^), chiefly of red granite.

Station 304. — Lat. 75° 3′ N., long. 4° 51′ E.; d. 1735 fms. (3173 m.); b.-t. — 1.5°. No bottom-sample.

Station 305. — Lat. 75° 1′ N., long. 7° 56′ E.; d. 1590 fms. (2908 m.); b.-t. — 1.5°. Biloculina clay on a thin layer of dark-grey clay, containing a few pebbles of argillaceous schist. The Biloculina clay was in two layers, like the sample from Station 245.

Station 306. — Lat. 75° 0′ N., long. 10° 27′ E.; d. 1334 fms. (2440 m.); b.-t. — 1.3°. Biloculina clay containing many *Biloculinæ*, and a pebble of argillaceous schist (weighing 1.5^gr^) imbedded in red, highly oxidized clay.

Station 307. — Lat. 74° 58′ N., long. 12° 10′ E.; d. 1216 fms. (2224 m.); b.-t. — 1.4°. Biloculina clay.

Station 308. N. B. 74° 57', Ø. L. 12° 43'. 1136 Fvn. (2078 M.). — 1.3°. Biloculinler med mange Biloculiner, stærkt brunt (oxyderet) paa Overfladen. Ingen Stene. Mange Globigeriner, ligesaa af Slægten *Lituola.*

Station 309. N. B. 74° 57', Ø. L. 13° 18'. 1065 Fvn. (1948 M.). — 1.3°. To Lag i Bundprøven. Øverst brungult Overgangsler, inderst graablaat Ler.

Station 310. N. B. 74° 56', Ø. L. 13° 50'. 1006 Fvn. (1840 M.). — 1.4°. En liden Prøve af brunt, ensartet Overgangsler. Faa Biloculiner. Ingen Stene.

Station 311. N. B. 74° 55', Ø. L. 14° 25'. 898 Fvn. (1642 M.). — 1.3°. Brunt Overgangsler med graat Underler. Ingen Stene.

Station 312. N. B. 74° 54', Ø. L. 14° 53'. 658 Fvn. (1203 M.). — 1.2°. Graat, mørkt Ler med Spor af brunt Ler. Ingen Stene.

Station 313. N. B. 74° 55', Ø. L. 15° 49'. 204 Fvn. (373 M.). 2.4°. Graat Ler.

Station 314. N. B. 74° 55', Ø. L. 15° 21'. 509 Fvn. (931 M.). — 0.6°. Graat Ler med noget brunt Sandler.

Station 315. N. B. 74° 53', Ø. L. 15° 55'. 180 Fvn. (329 M.). 2.5°. En liden Prøve af graat Ler med noget grønligt Ler (Rhabdamminaler).

Station 316. N. B. 74° 56', Ø. L. 16° 29'. 129 Fvn. (236 M.). 1.9°. Blaagraat Ler med lidt grønligt Ler. Mange Stene (veiende indtil 3 Gr.), bestaaende af Lerskifere, der ved Optagelsen var meget bløde.

Station 317. N. B. 74° 56', Ø. L. 16° 52'. 99 Fvn. (181 M.). 2.1°. En liden Prøve af mørkt blaagraat Ler. Ingen Stene.

Station 318. N. B. 74° 56', Ø. L. 17° 39'. 55 Fvn. (101 M.). 2.1°. En liden Prøve af grøngraat Ler (Rhabdamminaler).

Station 319. N. B. 74° 57', Ø. L. 18° 22'. 45 Fvn. (82 M.). 2.2°. Stenbund.

Station 320. N. B. 74° 57', Ø. L. 19° 8'. 31 Fvn. (57 M.). 0.9°. Stenbund.

Station 321. N. B. 74° 56', Ø. L. 19° 30'. 25 Fvn. (46 M.). 0.2°. Stenbund.

Station 308. — Lat. 74° 57' N., long. 12° 43' E.; d. 1136 fms. (2078 m.); b.-t. — 1.3°. Biloculina clay with a dark-brown surface (oxidized), containing many *Globigerinæ* and other Foraminifera of the genus *Lituola.* No pebbles.

Station 309. — Lat. 74° 57' N., long. 13° 18' E.; d. 1065 fms. (1948 m.); b.-t. — 1.3°. Two layers, — the upper a brownish-yellow Biloculina clay, the under a greyish-blue clay.

Station 310. — Lat. 74° 56' N., long. 13° 50' E.; d. 1006 fms. (1840 m.); b.-t. — 1.4°. A small sample of brown, homogeneous transition clay containing a few *Biloculinæ.* No pebbles.

Station 311. — Lat. 74° 55' N., long. 14° 25' E.; d. 898 fms. (1642 m.); b.-t. — 1.3°. A brown transition clay on a layer of grey clay. No pebbles.

Station 312. — Lat. 74° 54' N., long. 14° 53' E.; d. 658 fms. (1203 m.); b.-t. — 1.2°. A dark-grey clay with traces of a brown clay. No pebbles.

Station 313. — Lat. 74° 55' N., long. 15° 49' E.; d. 204 fms. (373 m.); b.-t. 2.4°. A grey clay.

Station 314. — Lat. 74° 55' N., long. 15° 21' E.; d. 509 fms. (931 m.); b.-t. — 1.6°. A grey clay along with a little brown, sabulous clay.

Station 315. — Lat. 74° 53' N., long. 15° 55' E.; d. 180 fms. (329 m.); b.-t. 2.5°. A small sample of grey clay along with a little greenish clay (Rhabdammina).

Station 316. — Lat. 74° 56' N., long. 16° 29' E.; d. 129 fms. (236 m.); b.-t. 1.9°. A bluish-grey clay along with a little greenish clay, containing together many pebbles (the largest weighing 3gr) of argillaceous schist. Previous to drying, the schist was exceedingly soft.

Station 317. — Lat. 74° 56' N., long. 16° 52' E.; d. 99 fms. (181 m.); b.-t. 2.1°. A small sample of dark bluish-grey clay. No pebbles.

Station 318. — Lat. 74° 56' N., long. 17° 39' E.; d. 55 fms. (101 m.); b.-t. 2.1°. A small sample of greenish-grey clay (Rhabdammina).

Station 319. — Lat. 74° 57' N., long. 18° 22' E.; d. 45 fms. (82 m.); b.-t. 2.2°. Bottom stony.

Station 320. — Lat. 74° 57' N., long. 19° 8' E.; d. 31 fms. (57 m.); b.-t. 0.9°. Bottom stony.

Station 321. — Lat. 74° 56' N., long. 19° 30' E.; d. 25 fms. (46 m.); b.-t. 0.2°. Bottom stony.

Station 322. N. B. 74° 57′, Ø. L. 19° 52′. 21 Fvn. (38 M.). 0.2°. Stenbund.

Station 323. N. B. 72° 53′, Ø. L. 21° 51′. 223 Fvn. (408 M.). 1.5°. Graat Ler.

Station 324. N. B. 73° 47′, Ø. L. 20° 48′. 233 Fvn. (426 M.). 0.9°. Grøngraat Rhabdammina-Ler med blaagraat fastere Underler. Mange Stene (veiende indtil 12 Gr.), bestaaende af Kvarts og Lerskifere.

Station 325. N. B. 74° 2′, Ø. L. 20° 30′. 90 Fvn. (165 M.). 0.9°. Mørkt, grøngraat Ler (Rhabd.-Ler).

Station 326. N. B. 75° 31′, Ø. L. 17° 50′. 123 Fvn. (225 M.). 1.6°. Graagrønt Rhabdammina-Ler. Ingen Stene.

Station 327. N. B. 75° 39′, Ø. L. 16° 33′. 188 Fvn. (344 M.). 0.7°. Ensartet, graat Ler. Ingen Stene.

Station 328. N. B. 75° 42′, Ø. L. 15° 39′. 200 Fvn. (366 M.). — 1.3°. Graat Ler.

Station 329. N. B. 75° 45′, Ø. L. 14° 45′. 199 Fvn. (364 M.). — 0.6°. Mørkt, graat Ler.

Station 330. N. B. 75° 48′, Ø. L. 13° 54′. 444 Fvn. (822 M.). 0.4°. Eiendommeligt, rødligt Ler med noget graat Ler. Ingen Stene.

Station 331. N. B. 75° 51′, Ø. L. 13° 5′. 795 Fvn. (1454 M.). — 1.3°. Rødligt Ler (?).

Station 332. N. B. 75° 56′, Ø. L. 11° 36′. 1149 Fvn. (2101 M.). — 1.5°. Blanding af Biloculinler og noget stærkt oxyderet, rødligt Ler. Faa Stene: Kvarts, Glimmer.

Station 333. N. B. 76° 6′, Ø. L. 13° 10′. 748 Fvn. (1368 M.). — 1.3°. Brunt Overgangsler med nogle enkelte Biloculiner. Ingen Stene.

Station 334. N. B. 76° 12′, Ø. L. 14° 0′. 403 Fvn. (737 M.). 1.0°. Brunt, sandholdigt Overgangsler med mange Kiselspikuler af Svampe. Mange Stene (veiende indtil 2 Gr.), bestaaende af Kvarts og Lerskifer.

Station 335. N. B. 76° 16′, Ø. L. 14° 39′. 179 Fvn. (326 M.). 1.0°. Graagrønt Ler med mange Stene (veiende indtil 4 Gr.), bestaaende af: Kvarts, *Flint*, Sandsten, Lerskifer.

Station 336. N. B. 76° 19′, Ø. L. 15° 42′. 70

Station 322. — Lat. 74° 57′ N., long. 19° 52′ E.; d. 21 fms. (38 m.); b.-t. 0.2°. Bottom stony.

Station 323. — Lat. 72° 53′ N., long. 21° 51′ E.; d. 223 fms. (408 m.); b.-t. 1.5°. A grey clay.

Station 324. — Lat. 73° 47′ N., long. 20° 48′ E.; d. 233 fms. (426 m.); b.-t. 0.9°. A greenish-grey Rhabdammina clay on a layer of firmer, bluish-grey clay containing together many pebbles (the largest weighing 12 gr) of quartz and argillaceous schist.

Station 325. — Lat. 74° 2′ N., long. 20° 30′ E.; d. 90 fms. (165 m.); b.-t. 0.9°. A dark greenish-grey clay.

Station 326. — Lat. 75° 31′ N., long. 17° 50′ E.; d. 123 fms. (225 m.); b.-t. 1.6°. A greyish-green Rhabdammina clay. No pebbles.

Station 327. — Lat. 75° 39′ N., long. 16° 33′ E.; d. 188 fms. (344 m.); b.-t. 0.7°. A grey homogeneous clay. No pebbles.

Station 328. — Lat. 75° 42′ N., long. 15° 39′ E.; d. 200 fms. (366 m.); b.-t. — 1.3°. A grey clay.

Station 329. — Lat. 75° 45′ N., long. 14° 45′ E.; d. 199 fms. (364 m.); b.-t. — 0.6°. A dark-grey clay.

Station 330. — Lat. 75° 48′ N., long. 13° 54′ E.; d. 444 fms. (812 m.); b.-t. 0.4°. A peculiar reddish clay along with a little grey clay. No pebbles.

Station 331. — Lat. 75° 51′ N., long. 13° 5′ E.; d. 795 fms. (1454 m.); b.-t. — 1.3°. A reddish clay (?).

Station 332. — Lat. 75° 56′ N., long. 11° 36′ E.; d. 1149 fms. (2101 m.); b.-t. — 1.5°. A mixture of Biloculina clay and a little highly oxidized reddish clay, containing together a few pebbles of quartz, mica.

Station 333. — Lat. 76° 6′ N., long. 13° 10′ E.; d. 748 fms. (1368 m.); b.-t. — 1.3°. A brown transition clay containing a few isolated *Biloculinæ*. No pebbles.

Station 334. — Lat. 76° 12′ N., long. 14° 0′ E.; d. 403 fms. (737 m.); b.-t. 1.0°. A brown, sabulous, transition clay containing many siliceous spicules of sponges and many pebbles (the largest weighing 2 gr) of quartz, argillaceous schist.

Station 335. — Lat. 76° 16′ N., long. 14° 39′ E.; d. 179 fms. (326 m.); b.-t. 1.0°. A greyish-green clay containing many pebbles (the largest weighing 4 gr) of quartz, *flint*, sandstone, argillaceous slate.

Station 336. — Lat. 76° 19′ N., long. 15° 42′ E.;

Fvn. (128 M.). 0.4°. Graat Ler. Mange Stene (veiende indtil 2 Gr.), bestaaende af forvitrende Granit og blød Lerskifer.

Station 337. N. B. 76° 23′, Ø. L. 16° 43′. 20 Fvn. (37 M.). 1.4°. Stenbund.

Station 338. N. B. 76° 19′, Ø. L. 18° 1′. 146 Fvn. (267 M.). — 1.1°. Stenbund.

Station 339. N. B. 76° 30′, Ø. L. 15° 39′. 37 Fvn. (68 M.). 0.9°. Stenbund.

Station 340. N. B. 76° 31′, Ø. L. 14° 40′. 58 Fvn. (106 M.). 0.6°. Graat, uensartet Ler. Mange Stene (veiende indtil 1 Gr.), bestaaende af Kvarts, Kvartsit, Lerskifer. Et lidet Stykke Stenkul.

Station 341. N. B. 76° 32′, Ø. L. 13° 53′. 118 Fvn. (216 M.). 0.8°. Yderst liden Prøve af graat Ler.

Station 342. N. B. 76° 33′, Ø. L. 13° 18′. 523 Fvn. (956 M.). — 1.0°. Brunt Overgangsler med graat Underler. Mange Stene (veiende indtil 3 Gr.), bestaaende af Kvarts og blød Lerskifer.

Station 343. N. B. 76° 34′, Ø. L. 12° 51′. 743 Fvn. (1359 M.). — 1.2°. Brunt Overgangsler med graat Underler. Nogle Stene (veiende indtil 3 Gr.), bestaaende af Kvarts, Glimmerskifer, Lerskifer.

Station 344. N. B. 76° 42′, Ø. L. 11° 16′. 1017 Fvn. (1860 M.). — 1.3°. Brunt Overgangsler. Ingen Globigeriner eller Biloculiner. Nogle faa Stene (veiende indtil 0.5 Gr.).

Station 347. N. B. 76° 40′, Ø. L. 7° 47′. 1429 Fvn. (2613 M.). — 1.3°. Biloculinler.

Station 349. N. B. 76° 30′, Ø. L. 2° 57′. 1487 Fvn. (2719 M.). — 1.5°. Mørkbrunt Biloculinler. Mange Stene (veiende indtil 3 Gr.), bestaaende af mørk Kvarts, krystallinske Skifere, Lerskifer.

Station 350. N. B. 76° 26′, V. L. 0° 29′. 1686 Fvn. (3083 M.). — 1.5°. Biloculinler.

Station 351. N. B. 77° 49′, V. L. 0° 9′. 1640 Fvn. (2999 M.). — 1.5°. Biloculinler.

Station 352. N. B. 77° 56′, Ø. L. 3° 29′. 1686 Fvn. (3083 M.). — 1.5°. Biloculinler. Mange Stene (veiende indtil 1.5 Gr.), bestaaende af Kvarts, Glimmerskifer, Granit, blød Lerskifer.

d. 70 fms. (128 m.); b.-t. 0.4°. A grey clay containing many pebbles (the largest weighing 2^gr^) of disintegrated granite and soft argillaceous schist.

Station 337. — Lat. 76° 23′ N., long. 16° 43′ E.; d. 20 fms. (37 m.); b.-t. 1.4°. Bottom stony.

Station 338. — Lat. 76° 19′ N., long. 18° 1′ E.; d. 146 fms. (267 m.); b.-t. — 1.1°. Bottom stony.

Station 339. — Lat. 76° 30′ N., long. 15° 39′ E.; d. 37 fms. (68 m.); b.-t. 0.9°. Bottom stony.

Station 340. — Lat. 76° 31′ N., long. 14° 40′ E.; d. 58 fms. (106 m.); b.-t. 0.6°. A grey clay containing many pebbles (the largest weighing 1 gr) of quartz, quartzite, argillaceous schist, and a small fragment of coal.

Station 341. — Lat. 76° 32′ N., long. 13° 53′ E.; 118 fms. (216 m.); b.-t. 0.8°. A very small sample of grey clay.

Station 342. — Lat. 76° 33′ N., long. 13° 18′ E.; d. 523 fms. (956 m.); b.-t. — 1.0°. A brown transition clay on a layer of grey clay containing many pebbles (the largest weighing 3 gr) of quartz and soft argillaceous schist.

Station 343. — Lat. 76° 34′ N., long. 12° 51′ E.; d. 743 fms. (1359 m.); b.-t. — 1.2°. A brown transition clay on a layer of grey clay containing a few pebbles (the largest weighing 3 gr) of quartz, mica, argillaceous schist.

Station 344. — Lat. 76° 42′ N., long. 11° 16′ E.; d. 1017 fms. (1860 m.); b.-t. — 1.3°. A brown transition clay containing a few pebbles (the largest weighing 0.5 gr). No *Globigerinæ* or *Biloculinæ*.

Station 347. — Lat. 76° 40′ N., long. 7° 47′ E.; d. 1429 fms. (2613 m.); b.-t. — 1.3°. Biloculina clay.

Station 349. — Lat. 76° 30′ N., long. 2° 57′ E.; d. 1487 fms. (2719 m.); b.-t. — 1.5°. A dark-brown Biloculina clay containing many pebbles (the largest weighing 3 gr) of dark quartz, crystalline schist, argillaceous schist.

Station 350. — Lat. 76° 26′ N., long. 0° 29′ W.; d. 1686 fms. (3083 m.); b.-t. — 1.5°. Biloculina clay.

Station 351. — Lat. 77° 49′ N., long. 0° 9′ W.; d. 1640 fms. (2999 m.); b.-t. — 1.5°. Biloculina clay.

Station 352. — Lat. 77° 56′ N., long. 3° 29′ W.; d. 1686 fms. (3083 m.); b.-t. — 1.5°. Biloculina clay containing many pebbles (the largest weighing 1.5 gr) of quartz, mica, granite, soft argillaceous clay.

Station 353. N. B. 77° 58', Ø. L. 5° 10'. 1333 Fvn. (2438 M.). — 1.4°. Biloculinler.

Station 354. N. B. 78° 1', Ø. L. 6° 54'. 1343 Fvn. (2451 M.). — 1.3°. Biloculinler med graat Underler; det sidste overveiende. I det graa Ler nogle Biloculiner.

Station 355. N. B. 78° 0', Ø. L. 8° 32'. 948 Fvn. (1734 M.). — 1.3°. Brunt Overgangsler med blaagraat Underler.

Station 356. N. B. 78° 2', Ø. L. 10° 19'. 110 Fvn. (204 M.). 2.1°. En liden Prøve af graat Ler. Mange Stene (veiende indtil 2 Gr.), bestaaende af Kvarts, *Flint*, Sandsten, Granit.

Station 357. N. B. 78° 3', Ø. L. 11° 18'. 125 Fvn. (229 M.). 1.9°. Nogenlunde ensartet, finkornigt, graat Ler. Faa Stene (veiende indtil 0.5 Gr.), bestaaende hovedsagelig af Lerskifer.

Station 358. N. B. 78° 2', Ø. L. 9° 46'. 93 Fvn. (170 M.). 2.6°. En liden Prøve af graat, uensartet Ler. Mange Stene (veiende indtil 8 Gr.), bestaaende af Kvarts, Sandsten, blød og haard Lerskifer.

Station 359. N. B. 78° 2', Ø. L. 9° 25'. 416 Fvn. (761 M.). 0.8°. Brunt Overgangsler med graasort Underler; det første overveiende. Nogle Stene, bestaaende af Glimmerskifer, Sandsten, Kvarts, Lerskifer, Asbest.

Station 360. N. B. 78° 47', Ø. L. 6° 58'. 421 Fvn. (770 M.). 0.0°. Stenbund.

Station 361. N. B. 79° 8', Ø. L. 5° 28'. 905 Fvn. (1655 M.). — 1.2°. Graat Ler. Ingen Stene.

Station 362. N. B. 79° 59', Ø. L. 5° 40'. 459 Fvn. (839 M.). — 1.0°. Blaagraat Ler.

Station 363. N. B. 80° 0', Ø. L. 8° 15'. 260 Fvn. (475 M.). 1.1°. Blaagraat Ler.

Station 364. N. B. 79° 48', Ø. L. 10° 50'. 195 Fvn. (357 M.). 2.3°. Bundprøven bestod hovedsagelig af Skjæl.

Station 365. N. B. 79° 34', Ø. L. 11° 25'. 74 Fvn. (135 M.). — 1.8°. Mørkgraat Ler.

Station 366. Magdalena Bay. N. B. 79° 35', Ø. L. 11° 17'. 61 Fvn. (112 M.). — 2.1°. Graat Ler.

Station 367. N. B. 78° 44', Ø. L. 7° 46'. 535

Station 353. — Lat. 77° 58' N., long. 5° 10' W.; d. 1333 fms. (2438 m.); b.-t. — 1.4°. Biloculina clay.

Station 354. — Lat. 78° 1' N., long. 6° 54' E.; d. 1343 fms. (2456 m.); b.-t. — 1.3°. Biloculina clay on a layer of grey clay, the latter constituting the greater part of the sample. A few *Biloculinæ* in the grey clay.

Station 355. — Lat. 78° 0' N., long. 8° 32' E.; d. 948 fms. (1734 m.); b.-t. — 1.3°. A brown transition clay on a layer of bluish-grey clay.

Station 356. — Lat. 78° 2' N., long. 10° 19' E.; d. 110 fms. (201 m.); b.-t. 2.1°. A small sample of grey clay containing many pebbles (the largest weighing 2 gr) of quartz, *flint*, sandstone, granite.

Station 357. — Lat. 78° 3' N., long. 11° 18' E.; d. 125 fms. (229 m.); b.-t. 1.9°. A fine, grey, comparatively homogeneous clay containing a few pebbles (the largest weighing 0.5 gr), chiefly of argillaceous schist.

Station 358. — Lat. 78° 2' N., long. 9° 46' E.; d. 93 fms. (170 m.); b.-t. 2.6°. A small sample of grey clay containing many pebbles (the largest weighing 8 gr) of quartz, sandstone, soft and hard argillaceous schist.

Station 359. — Lat. 78° 2' N., long. 9° 25' E.; d. 416 fms. (761 m.); b.-t. 0.8°. Biloculina clay on a thin layer of greyish-black clay containing a few pebbles of mica schist, sandstone, quartz, argillaceous schist, asbestos.

Station 360. — Lat. 78° 47' N., long. 6° 58' E.; d. 421 fms. (770 m.); b.-t. 0.0°. Bottom stony.

Station 361. — Lat. 79° 8' N., long. 5° 28' E.; d. 905 fms. (1655 m.); b.-t. — 1.2°. A grey clay. No pebbles.

Station 362. — Lat. 79° 59' N., long. 5° 40' E.; d. 459 fms. (839 m.); b.-t. — 1.0°. A bluish-grey clay.

Station 363. — Lat. 80° 0' N., long. 8° 15' E.; d. 260 fms. (475 m.); b.-t. 1.1°. A bluish-grey clay.

Station 364. — Lat. 79° 48' N., long. 10° 50' E.; d. 195 fms. (357 m.); b.-t. 2.3°. This sample consisted chiefly of calcareous shells.

Station 365. — Lat. 79° 34' N., long. 11° 25' E.; d. 74 fms. (135 m.); b.-t. — 1.8°. A dark-grey clay.

Station 366 (Magdalena Bay). — Lat. 79° 35' N., long. 11° 17' E.; d. 61 fms. (112 m.); b.-t. — 2.1°. A grey clay.

Station 367. — Lat. 78° 44' N., long. 7° 46' E.;

Fvn. (978 M.). — 0.7°. Graat Ler med lidt brunt Sandler. Mange Stene (veiende indtil 0.5 Gr.), bestaaende af krystallinske Skifere.

Station 368. N. B. 78° 43′, Ø. L. 8° 20′. 315 Fvn. (576 M.). 1.6°. Blaagraat, uensartet Ler. En Mængde Stene (veiende indtil 2.5 Gr.), bestaaende af Kvarts, Granit, haard Lerskifer.

Station 369. N. B. 78° 42′, Ø. L. 8° 53′. 87 Fvn. (159 M.). 0.8°. En liden Prøve af graat Ler. En Sten: Sandsten (veiende 8 Gr.).

Station 370. N. B. 78° 48′, Ø. L. 8° 37′. 109 Fvn. (199 M.). 1.1°. Graat Ler. Mange Stene (veiende indtil 3 Gr.), bestaaende af Kvarts, Kvartsit, Sandsten, blød Lerskifer.

Station 371. N. B. 78° 8′, Ø. L. 13° 46′. 197 Fvn. (360 M.). — 0.5°. Graat, fint Ler.

Station 372. N. B. 78° 9′, Ø. L. 14° 7′. 129 Fvn. (236 M.). 1.2°. Mørkgraat Ler.

Station 373. N. B. 78° 10′, Ø. L. 14° 21′. 120 Fvn. (219 M.). 0.8°. Mørkgraat Ler. Nogle Stene (veiende indtil 1 Gr.), bestaaende af krystallinske Skifere.

Station 374. N. B. 78° 16′, Ø. L. 15° 33′. 60 Fvn. (110 M.). 0.7°. Mørkgraat Ler.

Station 375. N. B. 75° 30′, Ø. L. 15° 3′. 204 Fvn. (373 M.). — 0.4°. Isfjorden. Mørkgraat Ler. Ingen Stene.

d. 535 fms. (978 m.); b.-t. — 0.7°. A grey clay along with a little brown, sabulous clay, containing together many pebbles (the largest weighing 0.5^{gr}) of crystalline schists.

Station 368. — Lat. 78° 43′ N., long. 8° 20′ E.; d. 315 fms. (576 m.); b.-t. 1.6°. A bluish-grey clay containing a great many pebbles (the largest weighing 2.5^{gr}) of quartz, granite, hard argillaceous schist.

Station 369. — Lat. 78° 42′ N., long. 8° 53′ E.; d. 87 fms. (159 m.); b.-t. 0.8°. A small sample of grey clay containing a fragment of sandstone, weighing 8^{gr}.

Station 370. — Lat. 78° 48′ N., long. 8° 37′ E.; d. 109 fms. (199 m.); b.-t. 1.1°. A grey clay containing many pebbles (the largest weighing 3^{gr}) of quartz, quartzite, sandstone, soft argillaceous schist.

Station 371. — Lat. 78° 8′ N., long. 13° 46′ E.; d. 197 fms. (360 m.); b.-t. — 0.5°. A fine, grey clay.

Station 372. — Lat. 78° 9′ N., long. 14° 7′ E.; d. 129 fms. (236 m.); b.-t. 1.2°. A dark-grey clay.

Station 373. — Lat. 78° 10′ N., long. 14° 21′ E.; d. 120 fms. (219 m.); b.-t. 0.8°. A dark-grey clay containing a few pebbles (the largest weighing 1^{gr}) of crystalline schists.

Station 374. — Lat. 78° 16′ N., long. 15° 33′ E.; d. 60 fms. (110 m.); b.-t. 0.7°. A dark-grey clay.

Station 375 (Ice Sound). — Lat. 75° 30′ N., long. 15° 3′ E.; d. 204 fms. (373 m.); b.-t. — 0.4°. A dark-grey clay. No pebbles.

Ved nærværende Afhandling er Bundprøverne væsentlig betragtede fra et kemisk Standpunkt. En grundig mikroskopisk Undersøgelse af Slammet med Hensyn til dets forskjellige Bestanddele vilde visselig være af Interesse, men kommer for Øieblikket til at træde i Baggrunden, da jeg endnu ikke har faaet Anledning til at gjøre det nødvendige Forstudium for dette specielle Emne. Men hvis Leilighed dertil gives, kommer jeg maaske senere til at undersøge Expeditionens righoldige Materiale ogsaa i denne Retning. Før der arbeides videre, vil det imidlertid være tjenlig at afvente Resultaterne af Bundprøvernes zoologiske Behandling ved Hr. Professor Sars, ligesom man maa være berettiget til at formode, at Hr. Prof. Mohns Undersøgelser af Havets fysiske Forhold maa kunne kaste Lys over mangt et Spørgsmaal med Hensyn til Slamarternes Udbredelse. Thi vi ved, at mange forskjellige Kræfter kan bidrage til Sedimenternes Dannelse og Afleiring, og for at belyse dem paa en alsidig Maade er det nødvendigt at tage flere af Naturvidenskaberne til Hjælp. Det store Materiale af Bundprøver fra Expeditionens 375 Stationer frembyder rig Anledning til et fortsat Studium. For den kemiske Undersøgelse har de Sedimenter, der forekommer i den fineste og mest ensartede Tilstand, størst Interesse. Jeg har derfor væsentlig lagt Vægten paa det egentlige Dybvandsslam — Biloculinleret —, der desuden ogsaa er det mest ubekjendte. Kystbankernes Afleiringer har jeg derimod taget mindre Hensyn til, da allerede Udseendet viser, at deres kemiske Sammensætning maa være altfor vexlende til, at at det i Almindelighed skulde være Umagen værd at underkaste dem en fuldstændig kemisk Analyse. I mineralogisk Retning har de allerede tidligere været Gjenstand for talrige Undersøgelser.

Rhabdammina-Leret frembyder derimod paa Grund af Forekomststedet og sit særegne Udseende en større Interesse.

For at udføre en fuldstændig kemisk Analyse af Bundprøverne, er jeg gaaet frem paa følgende Maade:

Paa forskjellige Punkter af Bundprøven udtages nogle Stykker, der pulveriseredes og udvadskedes med Vand for

In this Memoir, the samples of the bottom are regarded chiefly from a chemical point of view. A microscopic examination of the deposit — ooze, mud, or clay — to ascertain the various substances composing it, would unquestionably be attended with interesting results, but cannot, for lack of time and special acquaintance with the subject, be undertaken here. Meanwhile, I may perhaps on some future occasion so investigate the large amount of material collected on the North-Atlantic Expedition. Before proceeding further in that direction, it will however be best to await the results of Professor Sars's zoological treatment of the samples of the bottom, as there is also good reason to believe that Professor Mohn, in his observations to determine the physical conditions of the sea, will throw light on much that is now dubious respecting the distribution of oceanic deposits. We know that divers widely different forces contribute to form the surface-layers of the bottom, and must, therefore, for a full explanation of the phenomena have recourse to several branches of natural science. The rich collection of material obtained on the Norwegian Expedition, at 375 observing-stations, affords ample means for studying the nature of the substances distributed over the bed of the North-Atlantic. As regards the chemical investigation of the samples, it is the finest and comparatively homogeneous deposit that, when submitted to analysis, may be expected to give the most interesting results. Hence, I have laid especial stress upon the necessity of thoroughly investigating the deep-sea or Biloculina clay, — which besides is the least known of oceanic deposits. To the surface-layers of the coastal banks, on the other hand, comparatively little attention has been paid, their outward aspect being of itself sufficient to show that, as a rule, they will not repay the trouble of a rigorous analysis, by reason of the varying character of their constituents. The mineralogical features of these coastal deposits have been repeatedly determined.

Rhabdammina clay has a peculiar and easily recognizable appearance, which gives it accordingly so far exceptional interest.

When submitting the samples of the bottom to rigorous analysis, I went to work as follows: —

Portions of the sample were picked out at different points, pulverized, and washed several times in distilled

at fjerne det vedhængende Søsalt. Ganske fuldstændig sker dette først ved Kogning, men ved Analyserne er forresten en Behandling med koldt Vand tilstrækkelig, da det kun er forsvindende Mængder af Salt, som bliver tilbage i Leret.

Bundprøverne tørredes derpaa ved omtrent 100° C.[1] Nogle Gram udtoges og glødedes i en Platindigel i Perrot's Ovn til konstant Vægt, for at bestemme Vand og organiske Stoffe (Glødningstab). Af den samme Prøve afveiedes 5 eller 10 Gr. — alt efter Lerets Ensartethed — og kogtes i en Kolbe med 80 eller 40 Kc. fortyndet Saltsyre (20 pCt.) i omtrent et Kvarter.

Ved nøiagtig at anvende denne samme Behandlingsmaade ved de forskjellige Analyser faar man nogenlunde overensstemmende Resultater for den dekomponerbare Del af Bundprøven, især ved de finere Slamarter (Biloculinler). Ved nogle Kontrolanalyser, jeg har udført for at forsikre mig om Rigtigheden heraf, har jeg ikke faaet nogen større Variation end 2--3 pCt.

Filtratet fra det saltsure Udtræk fortyndedes til 500 eller 250 Kc. Med en Pipette udtoges af Opløsningen 50 eller 25 Kc., hvori Jern, Lerjord, Kalk og Magnesia bestemtes ved de sædvanlige Fældningsmidler.

En foregaaende Inddampning for at fjerne den opløste Kiselsyre blev tildels udført, men er forøvrigt unødvendig, da denne Bestanddel af Bundprøven kun forekommer sporvis i det saltsure Udtræk.

I en anden Portion bestemtes Jernoxydul ved Titrering med Kamæleon; den samlede Jernmængde fandtes paa samme Vis efter Reduktion med Zink.

Det i Saltsyre uopløste Residuum udkogtes med en Opløsning af kulsurt Natron til Bestemmelsen af Kiselsyren i de dekomponerede Silicater, blev derpaa glødet til konstant Vægt i Perrot's Ovn og veiet. En Del deraf (0.8 til 0.9 Gr.) opsluttedes med kulsurt Kali-Natron, Kiselsyren fraskiltes, og af Filtratet udfældtes Lerjord + Jern og Magnesia paa almindelig Maade. Det første Bundfald opløstes efter Veiningen i koncentreret Saltsyre[2], Jernet bestemtes derpaa ved Fældning med Ammoniak, efterat Lerjorden var fjernet med Natronlud.

For med Hurtighed at kunne bestemme Mængden af

[1] Hvad enten man anvender 100° eller 110°, gjør ingen væsentlig Forskjel.

[2] Ved denne Behandling kan det være vanskeligt at faa Bundfaldet fuldstændig opløst, men dette er heller ikke nødvendigt, da det tilbageblevne uopløste væsentlig bestaar af Lerjord; selv om denne skulde indeholde smaa Mængder af Jern, er den ialfald ved Behandlingen med Saltsyre blevet skikket til at paavirkes af Natronlud, hvorved Jernoxydet bliver uopløst. Dette har jeg ved Forsøg overbevist mig om.

water, to get rid of the salts. This cannot however be done entirely without boiling the mass; but for ordinary chemical analyses, repeated washing in cold water is quite sufficient, the residue of salt still remaining in the substance being hardly appreciable.

The portion of deposit was then dried at about 100° C.[1], after which a few grammes, placed in a platina crucible, were thoroughly heated in one of Perrot's furnaces, to determine the proportion of water and organic substances (loss by ignition). From the same portion, 5 or 10 grammes — according as the deposit was more or less homogeneous in character — were next weighed off and boiled in a flask, for about a quarter of an hour, along with 80^{cc} or 40^{cc} of diluted hydrochloric acid (20 per cent).

By exclusively adopting this method, fairly congruous results may be obtained for the decomposable part of the substance analysed, especially as regards the finer deposits (Biloculina clay). With divers test-analyses specially made to substantiate the trustworthiness of the process in question, the greatest difference did not exceed 2 or 3 per cent.

After dissolving the sediment filtered from the decoction with hydrochloric acid, and diluting the fluid till its volume had reached 500^{cc} or. 250^{cc}, the iron, alumina, lime, and magnesia in 50^{cc} or 25^{cc} of the solution — drawn off with a pipette — were determined in the usual manner.

Previous evaporation, to get rid of the silicic acid, was had recourse to for some of the analyses, though such is not strictly necessary, traces only of that constituent occurring in the decoction.

In another portion of the same sample, protoxide of iron was determined by titrating with permanganate of potash, and the total amount of iron in like manner after desoxidation with zinc.

The residue insoluble in hydrochloric acid was boiled along with a solution of carbonate of soda, to determine the proportion of silicic acid present in the decomposed silicates, and was then thoroughly heated in one of Perrot's furnaces, and weighed. Part of it (0.8—0.9 gramme) was fused with carbonate of potash and soda, the silicic acid got rid of, and alumina, iron, and magnesia precipitated in the usual manner. The first deposit was dissolved, after weighing, in concentrated hydrochloric acid,[2] and the iron then present determined by precipitation with ammonia, the alumina having been previously abstracted by means of soda-lye.

To determine in a short space of time the proportion

[1] Whether at 100° or 110° makes very little difference.

[2] Thus treated, it may be difficult to dissolve the whole of the deposit; but this is not necessary, the undissolved residue consisting chiefly of alumina; and even if it should contain minute quantities of iron, the treatment with hydrochloric acid will have rendered it susceptible to the action of soda-lye, causing the oxide of iron to remain undissolved. Of this I have satisfied myself by direct experiment.

den kulsure Kalk i Leret har jeg benyttet et af S. W. Johnson konstrueret Apparat (Zeitschrift für anal. Chemie, 9, S. 90). Dette er fortrinlig skikket til en hurtig og sikker Bestemmelse af Kulsyren i de let dekomponerbare Karbonater. Johnsons Apparat har den Fordel fremfor

Bunsens og de øvrige, at det ikke nødvendiggjør nogen Udsugning og Udkogning for at fjerne den tilbageblevne Kulsyre. Apparatet (se ovenstaaende Tegning) med den afveiede Substans fyldes (gjennem *a*) med tør Kulsyre fra et Udviklingsapparat og veies; derpaa holdes det paaskraa, saa at Saltsyren fra det pæreformige Reservoir rinder over i Kolben. Naar Karbonatet er fuldstændig dekomponeret, ledes Kulsyre atter igjennem og Veiningen udføres paany. Bestemmelsen kræver neppe en halv Time.

Med Apparatet fandt jeg i kulsur Baryt ved to Bestemmelser: 22.27 pCt. og 22.20 pCt.; beregnet: 22.33 pCt.
I Bundpr. fra St. 300 fandtes ligesaa 2.46 pCt. og 2.55 pCt. CO_2
I — „ „ 53 — — 12.70 — 12.81 —
Altsaa en Nøiagtighed som ikke lader noget tilbage at ønske.

of carbonate of lime present in oceanic deposit, I made use of an instrument devised by S. W. Johnson (Zeitschrift für anal. Chemie, 9, S. 90), and admirably adapted for speedy and accurate determination of the carbonic acid in easily decomposable carbonates. Johnson's apparatus has this advantage over Bunsen's and other instruments of the kind, that no absorptive, boiling-out process is necessary to get rid of the residuary carbonic acid. The apparatus in question (see Fig.), containing a given quantity of the substance, is filled (through *a*) with dry carbonic acid, and duly weighed; it is then held obliquely, that the hydrochloric acid from the pyriform reservoir may flow into the flask. So soon as the carbonate of lime is completely decomposed, the carbonic acid is again conducted through the apparatus, and the weighing carried out as before. Half an hour will amply suffice for the operation.

With this apparatus, I found in carbonate of baryta, as the result of two determinations, respectively 22.27 per cent and 22.20 per cent of carbonic acid (by computation 22.33 per cent). Again, in the sample of the bottom brought up at Station 300, the proportion thus determined was 2.46 per cent and 2.55 per cent; in that from Station 53, 12.70 per cent and 12.81 per cent, — a degree of accuracy that leaves nothing to be desired.

Da Farven er et karakteristisk Kjendemærke for den ydre Adskillelse af de forskjellige Sedimenter, maa det være af Interesse at kjende deres dermed sammenhængende kemiske Egenskaber. I denne Anledning maa vi rette vor Opmærksomhed mod den Oxydationsgrad, hvori Lerets Jernmængder befinder sig.

For at faa saa mange Observationer som muligt i denne Retning har jeg samtidig med Kalkbestemmelserne tilberedt mig et saltsurt Udtræk (paa den forud omtalte Maade) af den samme Prøve, hvis Kulsyregehalt var fundet ved Johnsons Apparat. Jernoxydul er titreret med Kamæleon og Jernoxyd med undersvovlsyrligt Natron og Jodopløsning[1].

Som de senere Analyser vil vise, indeholder det saltsure Udtræk den væsentligste Del af Lerets samlede Jernmængde.

Graat Ler.

Undersøgelsen af de talrige Bundprøver (over 150), der er indsamlede paa Kystbankerne rundt det europæiske Nordhav, har godtgjort, at den graa (stundom blaagraa) Farve i Almindelighed er en fælles Egenskab for alle de Slamdannelser, der bedække disse grundere Dele af Havbunden. I andre Retninger er imidlertid dette graa Ler af en temmelig uligeartet Beskaffenhed.

Paa nogle Stationer finder vi det som en fin plastisk Masse, der ved Tørring trækker sig stærkt sammen og danner en haard Klump af en saadan Fasthed, at man ofte maa bruge en Hammer for at slaa den istykker. Andetsteds er Leret mere porøst og grovkornigt; det kryber kun lidet sammen ved Tørring og bliver blot løst sammenhængende.

Denne Uligeartethed er afhængig af Biblandingen af grovere Materiale i Form af Sand (Kvartskorn) og uorganiske Dyrelevninger.

Naar vi underkaster Leret en Slemning for at undersøge dets Blandingsforhold, faar vi et større eller mindre Residuum, der hovedsagelig indeholder Skaller eller Skalbrudstykker af kalkafsondrende Dyr og grovere mineralske Partikler. De sidste bestaar som oftest for en væsentlig Del af smaa Kvartskorn, der i Almindelighed er noget afrundede i Kanterne. I hvilken høi Grad dette uforgjængelige Mineral er fremherskende fremfor de øvrige i Afleiringerne paa de grundere Dele af Havbunden, er paavist af Delesse i hans Værk: "Lithologie du fond des mers."

En paalidelig kvantitativ Slemningsanalyse lader sig vanskelig udføre i de tørrede Bundprøver. Ved Kogning med Vand kan man vistnok faa den faste Lermasse opblødt,

[1] Den sidste Methode kan vistnok ikke gjøre Fordring paa nogen stor Nøiagtighed, men maa dog ansees for tilfredsstillende ved det foreliggende Øiemed.

Colour being the chief external feature distinguishing oceanic deposits, it must obviously be of interest to learn whence that character is derived; and on investigating the subject, we find chemical agency to constitute the originating cause, — viz. the more or less advanced stage of oxidation in which the iron of the deposit occurs.

With a view to elucidate this question as fully as possible, I prepared, when performing the carbonate of lime determinations, a separate hydrochloric acid decoction (in the manner previously described) of the same sample of deposit in which the proportion of carbonic acid had been found with Johnson's apparatus. The protoxide of iron in this decoction was titrated with permanganate of potash and the sesquioxide with hyposulfite of soda and solution of iodine.[1]

From the subsequent analyses it will appear that the hydrochloric acid decoction contains the greater part of iron present in the deposit.

Grey Clays.

A comparative examination of the numerous samples of the bottom (upwards of 150) collected on the coastal banks of the North-Atlantic, has shown that, as a rule, the grey or bluish-grey colour constitutes a distinctive feature common to all sedimentary deposits covering the shallower portions of the sea-bed. In other respects, however, this clay differs very considerably.

At some of the observing-stations it was found to occur as a fine, plastic substance, which, when dried, contracts into a lumpy mass, so hard and compact that a hammer has frequently to be used for breaking it. In other localities, this coastal clay is more porous in character and coarsely granulated; it shrinks very little on exposure to heat, and has, when dry, but trifling cohesive power.

This want of homogeneity arises from the presence of coarser materials, such as sand (quartz) and inorganic animal remains.

On thoroughly washing the clay, to determine the extent of admixture, there will be found a greater or less residue, composed chiefly of calcareous shells or fragments of such and other mineral particles. Grains of quartz, as a rule rounded at the edges, generally constitute the greater part of the latter. The extent to which quartz predominates over other mineral substances as a constituent of oceanic deposit in the shallower parts of the sea-bed, has been shown by Delesse in his work "Lithologie du fond des mers."

To obtain a trustworthy determination of the various mechanical constituents in the clay by washing, is hardly practicable. The concrete substance of the deposit may, indeed,

[1] Titration by this method does not indeed give a high degree of accuracy, but may for this purpose be regarded as yielding fairly satisfactory results.

men det er neppe muligt at bringe dens amorfe Partikler i en tilstækkelig fint fordelt Tilstand.

Det kunde synes naturligt at antage, at den Grad af Finhed, hvori Lerets mineralske Blandingsdele befinder sig, maatte staa i et lovmæssigt Forhold til Afstanden fra Land. I det store taget er dette ogsaa ganske rigtigt, nemlig naar der er Tale om længere Strækninger, eller hvis man altsaa sammenligner Bundprøver, der er optagne fjernt fra hinanden og paa forskjellige Dyb (f. Ex. paa Kystbankerne og i det egentlige Havbasin), men indenfor det graa Lers eget Omraade er den ovenanførte Regel neppe anvendelig. Kystsedimenternes Foranderlighed og Ubestemthed i denne Retning er tidligere paavist ved talrige Observationer, og Bundprøverne fra den norske Expedition tjener til Bekræftelse herpaa.

Jeg skal saaledes exempelvis nævne, at vi ved Expeditionens sydligste Rute — fra Sognefjordens Munding til Island — paa Stationerne 8 og 9, der ligger 4—5 Mile fra Land, finder en fin ensartet Prøve, der udelukkende bestaar af amorft Ler, medens derimod Stationerne 14 og 18 — omkring 7 og 18 Mile længere ud i Havet — viser et grovkornigt Ler, der ved Slemning gav et betydeligt Residuum (30—40 pCt.) af grovere mineralske Partikler.

Det samme Forhold møder os ved Betragtningen af Bundprøverne fra Expeditionens nordligere Snit. Paa Stationerne 110, 114, 116, 117, 118 og 123 (15—30 Mile fra Land), har jeg saaledes ogsaa fundet fint- og grovkornigt Ler i et vexlende Forhold, der ikke synes at rette sig efter Afstanden fra Kysten. Denne Uregelmæssighed viser sig i det Hele taget overalt paa Kystbankerne, hvor Expeditionen har foretaget Dybdemaalinger fra Land og udover mod Havet i planmæssig Rækkefølge.

Af de Dyr, hvis uorganiske Rester forekommer i Kystleret, gives der naturligvis en Mangfoldighed af Arter, ligesom de ogsaa optræder i vexlende Antal, men sjelden udgjør de nogen væsentlig Del af Bundprøverne. Blandt de almindeligste af de Foraminiferer, der er fundne i Bundprøverne fra de norske Kystbanker, er Slægten *Uvigerina*[1]. Denne Foraminifer er sjeldnere i det graa Ler langs Spidsbergens Kyst, der i det Hele taget synes at være fattigere paa Dyrelevninger. Det kan nævnes, at jeg her paa enkelte Stationer har fundet *Discorbina* i et stort Antal.

Prøverne af graat Ler fra Færø-Islandsbanken viste sig at være næsten fuldkommen frie for Dyrelevninger.

I Havet nordenfor Norge er det vanskelig at bestemme Grændserne for det graa Lers Udbredelse, da det her støder sammen med og lidt efter lidt gaar over i det grønlige Rhabdammina-Ler. Langs Nordkysten af Norge er der af Expeditionen ikke foretaget nogen Dybdemaaling, men vi

[1] Jeg maa oplyse om, at Hr. Prof. Sars har været af den Godhed at bestemme disse i Leret forekommende Dyr, der især deleshed har tiltrukket sig min Opmærksomhed.

be macerated by boiling in water; but how reduce the amorphous matter to the requisite degree of fineness.

It seems reasonable to assume that the magnitude of the mineral constituents of the clay should be mainly determined by the distance from land. And, taken in a broad sense, this is found to be the case, viz. with regard to extensive tracts of the bottom, or, when comparing samples from widely distant localities and different depths (for example, the coastal banks as contrasted with the true ocean-basin); but within the limits of the grey clay formation the rule will hardly apply. The variable and uncertain character of shore-deposits in this respect, has previously been shown by numerous observations, and the samples of the bottom obtained on the Norwegian Expedition afford additional proof.

Thus, for instance, on the most southerly route of the Expedition — from the mouth of the Sognefjord to Iceland — samples of a fine, homogeneous deposit, consisting exclusively of amorphous clayey matter, came up at Stations 8 and 9, distant respectively 4 and 5 geographical miles from land, whereas at Stations 14 and 18, lying about 7 and 18 geographical miles farther out, the bottom was found to be covered with a coarsely granulated clay that, on being thorougly washed, left a very considerable residue (30 or 40 per cent) of coarse mineral particles.

A similar contrast is met with on comparing together the samples of the bottom from the northern section of the tract explored. Thus, at Stations 110, 114, 116, 117, 118, and 123 (from 15 to 30 geographical miles from land) I found finely and coarsely granulated clays occurring under conditions which are in no wise determined, it would seem, by the distance from the coast. This striking want of uniformity proved generally characteristic of coastal deposit wheresoever systematic series of soundings were taken from the shore to the banks.

The inorganic animal remains that occur in the grey coastal clay are referable to a great variety of species, more or less numerously represented, but they rarely constitute any considerable portion of the deposit. Among the Foraminifera found in the samples of the bottom from the Norwegian coastal banks, one of the genera of most frequent occurrence is *Uvigerina*.[1] This animal is comparatively rare in the grey clay off the coast of Spitzbergen, which indeed would appear to be less rich in animal remains. Here, however, at a few Stations, I found the deposit to contain great numbers of the shells of *Discorbina*.

The samples of grey clay from the Færoe-Iceland bank exhibit scarce a trace of animal remains.

In the tract of ocean stretching north of Norway, it is difficult to determine the exact limits for the distribution of the grey clay, since it there borders on, and is gradually merged into, the greenish-coloured Rhabdammina clay. Along the north coast of Norway no soundings were taken, but

[1] Professor G. O. Sars has had the kindness to determine such of the animals occurring in the clay as particularly attracted my attention.

har derimod flere Undersøgelsesstationer i de store Fjorde, der her skjærer sig ind i Landet.

I Altenfjorden fandtes et fint, lyst grøngraat Ler, i Porsangerfjorden et mørkt grønligt, der ligner Rhabdammina-Leret, og i Tanafjorden et ensartet, lysgraat Ler.

Den Del af Østhavets grunde Havbund, der i Syd for Beeren Eiland begynder at skraane ned mod det vestlige Dyb, er vistnok i Almindelighed bedækket af et graat Ler, men dette er ofte biblandet et brunt Sandler, der danner det øverste Lag af Sedimentet og stundom udgjør den overveiende Del af Bundprøven. Disse Uregelmæssigheder har jeg ved Tegningen af Kartet undladt at tage Hensyn til. Som det vil sees af dette, har jeg lagt det graa Ler som en Fortsættelse fra Norges Kystbanker opover mod Nord forbi Vestsiden af Beeren Eiland og videre langs Spidsbergens Kyst. Efter hvad der i det nærmest foregaaende er sagt, vil det imidlertid være indlysende, at de Grændser, jeg har trukket for det graa Lers Udbredelse imellem Norge og Beeren Eiland, er af en noget ubestemt Art eller ialfald maa betragtes med et vist Forbehold. Denne Usikkerhed ved Kartet indskrænker sig imidlertid til denne Del af Havbunden; de øvrige Grændsers Paalidelighed er sikret ved talrigere Stationer og ved en større Grad af Regelmæssighed med Hensyn til Sedimenternes Fordeling.

Det graa Ler langs Spidsbergen synes gjennemgaaende at være af en noget mørkere Farve end Norges Kystler, men hvad der forøvrigt er sagt om det sidste, gjælder i sin Almindelighed ogsaa om hint.

De Bundprøver, der udelukkende bestaar af graat Ler, er sjelden optagne paa nogen større Dybde end 400—450 Favne. Langs den nordlige Del af den norske Kyst findes der blot nogle faa Stationer, som danner Undtagelser fra denne Regel. De mest abnormale i denne Retning er Stationerne 134, 136 og 137[1], hvor vi finder det graa Ler indtil et Dyb af 844 Favne. Ved Betragtning af Dybdekartet over det norske Hav vil man se, at Havbunden, der hvor disse Stationer forekommer, viser en meget eiendommelig Formation. Kystbankerne, der langs Vesteraalen og Lofoten har en temmelig snever Udstrækning, udvider sig nemlig paa dette Sted temmelig pludselig til et større Omraade. Omkring de nævnte Stationer gjør Dybdekurven for 800 Favne en skarp og trang Bugt og fortsættes i en ny Retning, der næsten danner en ret Vinkel med dens foregaaende. Denne eiendommelige og interessante Form af Havbunden er meget nøiagtig bestemt ved talrige Dybdemaalinger. Som det senere skal omtales, fandtes der ogsaa i denne Bugt en Mængde Stene.

Paa de sydligere Dele af de norske Kystbanker synes det graa Ler i Almindelighed at gaa ned til større Dyb end længere Nord. I Øst for Island fandtes det graa Ler

[1] Disse Stationer ligger imellem 67° og 68° N. B. 8° og 9° Ø. L.

the Expedition had several observing-stations in the great fjords of that region.

In the Alten Fjord, the surface-layer of the bottom was found to consist of a fine, light-coloured, greenish-grey clay; in the Porsanger Fjord, of a dark, greenish clay, resembling Rhabdammina; and in the Tana Fjord, of a light-grey homogeneous clay.

The shallow bed of the East Sea, which, south of Beeren Eiland, begins to slope down towards the western depths, is, indeed, in that locality chiefly covered with a grey clay; but a brown, sabulous clay often occurs as the top layer of the deposit, and sometimes constitutes the principal part of the sample. Meanwhile, I had no regard to these exceptional characteristics when drawing the annexed map, in which the grey clay is shown to extend from the Norwegian coastal banks northward past the western shores of Beeren Eiland, and thence along the coast of Spitzbergen. From what has been stated above, it will, however, be apparent, that the limits I have traced for the distribution of the grey clay between Norway and Beeren Eiland are to a certain extent problematical, or should at least be regarded with some reservation. But this uncertainty does not extend to any other part of the sea-bed marked off on the map; numerous observing-stations, together with greater uniformity of distribution, vouch for accuracy as regards the outline of the remaining sections.

The grey clay occurring along the coast of Spitzbergen would appear to be somewhat darker in colour than the Norwegian shore-deposit; but for the rest, what has been observed respecting the latter, will as a rule apply with equal force to the former.

Samples of the bottom consisting exclusively of grey clay were rarely obtained from a greater depth than 400 to 450 fathoms. In some few localities, however, off the northern part of the Norwegian coast, this limit was considerably exceeded. The most notable exceptions to the rule occur at Stations 134, 136, and 137,[1] where the grey clay reaches as far down as 844 fathoms. On examining the Depth Chart, a very peculiar configuration will be seen to characterize the basin of the North Atlantic in the locality where those Stations are located. Here the coastal banks, comparatively narrow off Vesteraalen and Lofoten, suddenly expand. Round the aforesaid Stations, the curve of depth (800 fathoms) makes a sudden bend, after which it strikes off in a new direction well-nigh at right angles to that it had before. This singular and interesting feature in the contour of the ocean-bed has been accurately determined by numerous trustworthy soundings. Here, too, within the bend of the curve, the deposit contained a great many pebbles.

At the southern extremity of the Norwegian coastal banks, the grey clay would as a rule appear to attain a greater depth than at the northern. East of Iceland this

[1] Between lat. 67° N., long. 8° E. and lat. 68° N., long. 9° E.

paa 571 Favne; ligeledes forekom det paa Vestkysten af Spidsbergen i et usædvanligt Dyb (Stationerne 367 og 361, 535—905 Favne).

Som udgjørende en Del af Bundprøverne eller altsaa som det underliggende Lag af Sedimenterne er det graa Ler fundet paa de største Dybder. Dette skal nærmere omtales under Beskrivelsen af de øvrige Slamarter.

Stene fandtes ofte i Bundprøverne, især paa de grundere Steder. Beskrivelsen over deres Art og Udbredelse paa Kystbankerne, saavelsom paa de øvrige Dele af Havbunden, vil jeg gjøre til et særskilt Afsnit af denne Afhandling.

I kemisk Retning frembyder det graa Ler paa Grund af sin Uensartethed eller sit vexlende Blandingsforhold mindre Interesse end de finere Sedimenter. Lerets Kalkgehalt, der nærmest tiltrækker sig vor Opmærksomhed, retter sig naturligvis til en vis Grad efter dets Forraad paa uorganiske Dyrelevninger og udgjør derfor i Almindelighed ingen væsentlig Mængde i Forhold til de øvrige mineralske Bestanddele. Man finder imidlertid ikke sjelden, at Leret i sig selv har en ganske anseelig Kalkgehalt (indtil 20 pCt.), der ikke kan tilskrives de synlige, mekanisk biblandede Rester fra Dyrelivet.

I to forskjellige Bundprøver fra det graa Ler har jeg udført fuldstændige Analyser. Den ene Prøve (362) er fra Expeditionens næstnordligste Station og bestaar blot af graat Ler; den anden (213) er optaget indenfor Biloculinlerets Omraade fra dets underliggende Lag.

Station 362.

N. B. 79° 59′, Ø. L. 5° 40′. 459 Favne (839 Meter). Temperatur ved Bunden — 1.0°. Blaaliggraat, nogenlunde ensartet Ler. Næsten ingen uorganiske Dyrelevninger. Nogle smaa Stene.

	Glødningstab	4.13
Dekomponeret af Saltsyre 24.09 pCt.	Jernoxydul	2.98
	Jernoxyd	2.27
	Lerjord	7.66
	Kalk	0.28
	Magnesia	1.24
	Kulsur Kalk	4.02
	Fosforsyre	Spor
	Kiselsyre	5.64
Udekomponeret af Saltsyre 72.50 pCt.	Jernoxyd	1.51
	Lerjord	9.92
	Magnesia	Spor
	Kiselsyre	61.07
	Sum	100.72

deposit was met with as far down as 571 fathoms; and off the west coast of Spitzbergen it also occurs unusually deep (at Stations 367 and 361, 535—905 fathoms).

As constituting some portion of the samples, viz. their bottom layer, the grey clay has been brought up from the greatest depths. On this head I shall have more to say when describing the other deposits.

Pebbles were frequently found in the samples of the bottom, more especially in those from shallower localities. For investigating the nature of these constituents and their distribution alike on the coastal banks and elsewhere over the bed of the ocean-tract explored, a separate section of this Memoir will be devoted.

As a subject of chemical analysis, the grey clay, by reason of its want of homogeneity, or the extent to which it differs mechanically, is less interesting than the finer of the oceanic deposits. The amount of lime which, from a chemical point of view, chiefly attracts attention, must of course be more or less dependent on the proportion of inorganic animal remains, and from that source, therefore, as a rule, but trifling, as compared with the other mineral constituents. Meanwhile, this clay is not infrequently found to contain a very considerable portion of lime (as much as 20 per cent) which cannot be derived from perceptible calcareous remains of animals mechanically mixed with the deposit.

Of the grey clay, I have submitted two different samples to rigorous analysis. One of these came up at the most northerly Station (362), and consisted exclusively of grey clay; the other was obtained at Station 213, from the under layer of Biloculina clay.

Station 362.

Lat. 79° 59′ N., long. 5° 40′ E.; 459 fathoms (839 metres): bottom-temperature — 1.0°. A bluish-grey, comparatively homogeneous clay containing a few pebbles, but hardly any inorganic animal remains.

	Loss by ignition	4.13
Decomposed by Hydrochloric Acid 24.09 per cent.	Protoxide of iron	2.98
	Sesquioxide of iron	2.27
	Alumina	7.66
	Lime	0.28
	Magnesia	1.24
	Carbonate of lime	4.02
	Phosphoric acid	Traces
	Silica	5.64
Undecomposed by Hydrochloric Acid 72.50 per cent.	Sesquioxide of iron	1.51
	Alumina	9.92
	Magnesia	Traces
	Silica	61.07
		100.72

Samlede Bestanddele:

FeO[1]	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
2.98	3.78	17.58	0.28	1.24	4.02	Spor	66.71

Glødn.tab	Sum
4.13	100.72

Station 213.

N. B. 70° 23′, Ø. L. 2° 30′. 1760 Favne (3219 Meter). — 1.2°. Graat, yderst fint Ler, liggende under Biloculinleret, hvoraf der paa denne Station kun fandtes ganske smaa Mængder.

Lerets specifiske Vægt var 2.79.

	Glødningstab	5.59
Dekomponeret af Saltsyre 36.06 pCt.	Jernoxydul	3.06
	Jernoxyd	4.45
	Lerjord	6.32
	Kalk	1.20
	Magnesia	2.76
	Kulsur Kalk	4.27
	Fosforsyre	Spor
	Kiselsyre	14.00
Udekomponeret af Saltsyre 57.20 pCt.	Jernoxyd	2.72
	Lerjord	11.77
	Magnesia	1.59
	Kiselsyre	41.12
	Sum	98.85

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_2$	P_2O_5	SiO_2
3.06	7.17	18.09	1.20	4.35	4.27	Spor	55.12

Glødn.tab	Sum
5.59	98.85

I den følgende Tabel har jeg opstillet de Kalkbestemmelser, der ved Hjælp af Johnsons Apparat er udførte i Prøver fra det graa Ler, tilligemed Mængderne af Jernoxydul og Jernoxyd, som samtidig er fundne ved Titrering i det saltsure Udtræk. I de sidste Rubriker har jeg opført den samlede Jernmængde og Forholdet mellem Oxyderne, hvilket altsaa er et Udtryk for Lerets Oxydationsgrad. For Tabellen er ogsaa medtaget Undersøgelserne af det graa Ler fra nogle af de Stationer, hvor det forekommer som et underliggende Lag indenfor de andre Sedimenters Omraade. Oplysning derom er tilføiet under Anmærkninger.

[1] Jernoxydulmængden refererer sig her — ligesom i de følgende Analyser — blot til den af Saltsyre dekomponerede Del, da den ikke er bestemt i den uopløselige.

Foruden de ovenanførte Bestanddele fandtes i alle Bundprøverne Spor af Mangan i Residuet fra det saltsure Udtræk; dette indeholdt ogsaa i Almindelighed smaa Mængder af Kalk.

Constituents of Sample: —

FeO[1]	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
2.98	3.78	17.58	0.28	1.24	4.02	Traces	66.71

Loss by Ignition.
4.13 = 100.72.

Station 213.

Lat. 70° 23′ N., long. 2° 30′ E.; 1760 fathoms (3219 metres); bottom-temperature — 1.2°. A grey, exceedingly fine clay underlying the Biloculina clay that occurred very sparingly at this Station.

Specific Gravity of Sample 2.79.

	Loss by ignition	5.59
Decomposed by Hydrochloric acid 36.06 per cent.	Protoxide of iron	3.06
	Sesquioxide of iron	4.45
	Alumina	6.32
	Lime	1.20
	Magnesia	2.76
	Carbonate of lime	4.27
	Phosphoric acid	Traces
	Silica	14.00
Undecomposed by Hydrochloric acid 57.20 per cent.	Sesquioxide of iron	2.72
	Alumina	11.77
	Magnesia	1.59
	Silica	41.12
		98.85

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_2$	P_2O_5	SiO_2
3.06	7.17	18.09	1.20	4.35	4.27	Traces	55.12

Loss by Ignition.
5.59 = 98.85.

In the following Table I have given the amount of lime determined with Johnson's apparatus in samples of the grey clay, together with the proportion of protoxide and sequioxide of iron found by titration in the hydrochloric acid solution. The four right hand columns show the total amount of iron and relative proportion of each oxide, thus expressing the degree of oxidation in which the clay occurs. The results set forth in the Table also comprise those obtained on analysing grey clay from some of the localities where it constitutes an under layer of other oceanic deposits. Such samples are specified in the last column, headed "Remarks."

[1] The protoxide of iron refers exclusively, both here and in all subsequent analyses, to the amount decomposed by hydrochloric acid; in that remaining insoluble it was not determined.

Exclusive of the constituents specified above, all the samples of the bottom exhibited traces of manganese in the residue from the hydrochloric acid decoction, which also contained as a rule small quantities of lime.

Station.	Nordlig Bredde. (*N. Lat.*)	Længde fra Greenw. (*Long. f. Greenw.*)	Dybde i engl. Favne. (*Depth in Eng. Fath.*)	$CaCO_3$	Fe_2O_3	FeO	Samlet Fe (*Total Fe.*)	Fe_2O_3: FeO	Anmærkninger. (*Remarks.*)	
10	61° 41′	3° 19′ E.	220	20.41	3.56	1.59	3.72	2.24	Ingen synlige Kalkskaller.	*No perceptible Calcareous Shells.*
41	63 37	7 10 W.	697	8.13	6.37	3.98	7.56	1.60		
49	65 0	9 25 W.	437	6.50	5.09	3.47	6.26	1.47	Færø—Islandsbanken Ingen Kalkskaller.	*The Færoe-Iceland Bank. No Calcareous Shells.*
50	65 26	8 24 W.	571	10.32	4.59	2.19	4.91	2.09		
98	65 56	5 21 E.	388	17.27	2.24	1.90	3.05	1.18	Underliggende Lag (øverst brunt Ler).	*Under Layer; the Upper Brown Clay.*
107	65 21	10 44 E.	172	9.41	2.23	2.02	3.13	1.10	6—7 Mile fra Kysten.	*6 or 7 Miles from the Coast.*
213	70 23	2 30 E.	1760	4.27	4.45	3.06	5.49	1.45	Undrl. Lag (øv. Biloculinler).	*Under Layer; the Upper Biloc. Clay.*
266	71 27	35 39 E.	130	Spor. (*Traces.*)	2.57	2.45	3.71	1.02	Undrl. Lag (øv. Rhabdam.-Ler).	*Under Layer; the Upper Rhabd. Clay.*
289	72 41	20 18 E.	219	3.61	2.56	1.70	3.11	1.51		
301	74 1	1 20 W.	1684	0.45	. .	. .	. .	. .	Underliggende Lag (øverst Biloculinler).	*Under Layer; the Upper Layer Biloculina Clay.*
323	72 53	21 51 E.	223	2.15	3.38	2.28	4.14	1.48		
362	79 59	5 40 E.	459	4.02	2.27	2.98	3.91	0.76		
373	78 10	14 26 E.	120	6.13	2.43	3.00	4.49	0.68	Mørkgraat Ler. Isfjorden.	*Dark-grey Clay. Ice Sound.*

Det vil sees af de ovenanførte Analyser, at Lerets Kalkgehalt er meget variabel, men kun paa et Par Steder opnaar nogen betydeligere Størrelse.

De Tal, der udtrykker Lerets Oxydationsgrad, ligger paa faa Undtagelser nær mellem 1 og 2. Vi kan foreløbig betragte dette som et, med Farven sammenhængende, kemisk Kjendemærke, der kan tjene til at adskille det graa Ler fra de øvrige Sedimenter, hvis Forhold i den samme Retning senere skal belyses.

It will be seen from the above analyses that the proportion of lime varies exceedingly in this clay; but its absolute amount is not considerable save in one or two localities.

The figures expressing the degree of oxidation lie, with but few exceptions, between 1 and 2. This we may regard for the present as a chemical feature intimately connected with colour, that serves to distinguish all grey clays from the other deposits whose similarly derived characteristics I shall elucidate in turn.

Grønligt Ler.

(Rhabdammina-Ler).

Nordhavets østlige Del, der ligger imellem Norge, Beeren Eiland, Spidsbergen og Novaja Semlja, er af en meget ringe Dybde. En Hævning paa lidt over 400 Meter vilde være tilstrækkelig for at løfte dets Bund over Havets Overflade og forvandle den til et stort Sletteland.

De betydelige Strækninger af denne jevne Havbund, der af Expeditionen blev undersøgte, fandtes bedækkede af et Sediment — Rhabdammina-Ler —, som med Hensyn til Udseende og kemisk Beskaffenhed er af en eiendommelig Art. Mest karakteristisk finder vi det paa de østligste Sta-

Green Clays.

(Rhabdammina Clay).

The eastern section of the North Atlantic, between Norway, Beeren Eiland, Spitzbergen, and Novaja Zemlja, is exceedingly shallow. A rise of but little more than 400 metres would suffice to bring the whole of its bed above the surface of the sea and transform the tract into a vast plateau.

In the numerous localities of this extensive region, explored by the Norwegian Expedition, its level floor was found to be covered with a deposit — Rhabdammina clay — peculiar alike in outward appearance and chemical composition. Its characteristic features are most salient in the

tioner (omkring den 38te Længdegrad), hvor det fremtræder som et ensartet, temmelig fint Slam af en eiendommelig mørkgrøn Farve. Efter Tørring opnaar det kun en ubetydelig Fasthed eller Sammenhængskraft og kan mellem Fingrene knuses til et Pulver, der er at føle paa som et meget fint Sand.

Under Mikroskopet viser det sig for en væsentlig Del at bestaa af smaa Kvartskorn, der i Almindelighed er temmelig skarpkantede.

Af Dyrelevninger indeholder Slammet kun faa. Almindeligst finder man Rør af Annelider (udelukkende *Spiochetopterus),* Kiselspikuler af Svampe og Skaller af Slægten *Astarte,* foruden den omtalte Foraminifer *Rhabdammina,* der synes at være meget almindelig.

Det fremgaar af Bundprøverne fra Expeditionens østligste Stationer, at Rhabdammina-Leret her er af en ringe Mægtighed, da jeg nemlig paa flere Steder har fundet ét underliggende Lag af mørkgraat, finkornigt og mindre sandholdigt Ler.

Paa de vestligere Stationer taber Rhabdammina-Leret lidt efter lidt sine karakteristiske Egenskaber; det bliver mere plastisk og Farven mindre udpræget grønlig, ligesom heller ikke nogen Lagdannelse viser sig i Bundprøverne — indtil vi i Syd for Beeren Eiland (under 20—25° Ø. L.) gjenfinder det graa Ler. Nordenom denne Ø gaar Rhabdammina-Leret længere ud i Havet i vestlig Retning og naar her op til Spidsbergens Sydkyst.[1]

I kemisk Retning udmærker det grønlige Ler sig ved sin store Kiselsyremængde og ved den mindre oxyderte Tilstand, hvori det befinder sig. Jeg har troet at iagttage, at flere af Bundprøverne, ved at henligge i Luften (paa Laboratoriet), forandrer sit Udseende, og i en enkelt har jeg ad kemisk Vei konstateret, at den i pulveriseret Tilstand efter nogen Tids Forløb har tiltaget i Jernoxydgehalt, idet Farven samtidig er blevet brunlig. I Bundprøven fra Station 264 fandt jeg nemlig i det saltsure Udtræk ved den første Analyse: 2.48 pCt. FeO og blot 0.24 pCt. Fe_2O_3,[2] et halvt Aar senere erholdt jeg derimod: 1.00 pCt. FeO og 1.39 pCt. Fe_2O_3.

Da jeg har kontrolleret den sidste Bestemmelse og heller ikke har nogen Grund til at tvivle paa Rigtigheden af den første, synes dette mig at være et Fænomen, der er vel værd at lægge Mærke til.

I Rhabdammina-Leret har jeg udført fuldstændige Analyser af to Bundprøver fra Expeditionens østligste Rute,

[1] Rundt om Beeren Eiland vil man paa Kortet finde et aabent Rum. Her har Expeditionen foretaget flere Dybdemaalinger, der viser, at Bunden ikke ligger dybere end 100 Favne. Da Loddet næsten altid stødte mod Sten, blev ingen Bundprøve optaget.

[2] Den samlede Jernmængde er bestemt med Kamæleon efter Reduktion med Zink.

extreme eastern section of the tract (near the 38th parallel of latitude), where this deposit occurs as a homogeneous, comparatively fine mud of a peculiar dark-green colour. Friable when dried, it possesses very little cohesive power, admitting of being crushed between the fingers to powder, which has a gritty feel, like fine sand.

Examined under the microscope, it is minute, and, as a rule, comparatively sharp-edged particles of quartz are found to form its chief constituent.

Of animal remains this deposit contains but few. Those most frequently met with are tubes of Annelids (exclusively *Spiochetopterus),* siliceous spicules of sponges, and shells of the genus *Astarte,* as also of the previously mentioned Foraminifer *Rhabdammina,* which would appear to be comparatively numerous.

The deposit brought up at the most easterly of the observing-stations shows the surface-layer of Rhabdammina clay in that locality to be of trifling thickness; several of the samples had an under layer of dark-grey, finely granulated, and somewhat sabulous clay.

Throughout the western part of the tract, the Rhabdammina clay gradually loses its distinctive features, becoming more plastic in substance and in colour less characteristically green, with no appearance of stratification in the samples, — till, south of Beeren Eiland (long. 20° to 25° E.) we again meet with the grey clay. North of that island, the Rhabdammina clay extends farther seaward, reaching up to the south coast of Spitzbergen.[1]

Regarded chemically, the chief characteristics of this greenish clay are its large proportion of silica and the slight extent to which it is oxidized. On exposure to atmospheric influence (in the laboratory), several of the samples underwent, I feel pretty sure, a change of aspect; and in one, which had been pulverized and allowed to stand over for some time, I proved by direct analysis an increase in the amount of oxide of iron: its colour, too, had become brownish. Again, in the sample brought up at Station 264, I found in the hydrochloric acid decoction as the result of a first analysis, 2.48 per cent of FeO and only 0.24 per cent of Fe_2O_3;[2] but six months later the proportion determined was 1.00 per cent of FeO and 1.39 per cent of Fe_2O_3.

Having tested the results of the latter analysis and seeing no reason to doubt the accuracy of the first, I call attention to this phenomenon as one that should, I think, by no means pass disregarded.

Of the Rhabdammina clay met with on the eastern route of the Expedition, I have submitted to rigorous ana-

[1] Round the shores of Beeren Eiland a blank space has been left in the map. From several soundings taken here at different points, the depth was found not to exceed 100 fathoms; and the lead having almost invariably struck against rock or stone, no sample of the bottom could of course be obtained.

[2] The total amount of iron was determined with permanganate of potash, after desoxidation with zinc.

nemlig paa den omtalte Station 264 og paa Station 267, hvilke ligger omtrent 15 Mile fra hinanden.

Station 264.

N. B. 70° 56′, Ø. L. 35° 37′. 86 Favne (157 Meter). Temperatur ved Bunden 1.9°. Grøngraat, løst Ler med noget mørkgraat Underler. Talrige Annelider *(Spiochætopterus).* Ingen Stene.

	Glødningstab	1.85
Dekomponeret af Saltsyre 12.20 pCt.	Jernoxydul	2.48
	Jernoxyd	0.24
	Lerjord	1.72
	Kulsur Kalk	2.54
	Kulsur Magnesia	2.20
	Fosforsyre	Spor
	Kiselsyre	3.02
Udekomponeret af Saltsyre 85.33 pCt.	Jernoxyd	0.12
	Lerjord	1.01
	Magnesia	1.00
	Kiselsyre	83.20
	Sum	99.48

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$	P_2O_5	SiO_2
2.48	0.36	2.73	2.54	2.20	Spor	85.23

Glødn.tab	Sum
1.85	99.48

Den følgende Analyse viser en forholdsvis ringe Forskjellighed fra den første. Bundprøven fra Station 267 er imidlertid optaget paa et større Dyb.

Station 267.

N. B. 71° 42′, Ø. L. 37° 1′. 148 Favne (271 Meter). —1.4°. Løst, grøngraat Ler med noget mørkgraat Underler. I Bundprøven nogle Stene (veiende indtil 0.5 Gr.), bestaaende af Sandsten og Lerskifer. I Skraben fandtes paa denne Station mange større Stene: haard Skifer, Kvartsskifer, en pibet mørk Sten, Sten med Kisnyre, mørk graa Sandsten, rød Granit, chokoladebrun Tuf (?), mørk Lerskifer.

Lerets spec. Vægt var 2.59.

lysis two different samples, one from the Station previously mentioned, 264, and the other from Station 267, about 15 geographical miles apart.

Station 264.

Lat. 70° 56′ N., long. 35° 37′ E.; 86 fathoms (157 metres); bottom-temperature 1.9°. A greenish-grey, porous clay on a thin layer of dark-grey clay, containing numerous remains of tube-building Annelids *(Spiochætopterus)*; no pebbles.

	Loss by ignition	1.85
Decomposed by Hydrochloric acid 12.20 per cent.	Protoxide of iron	2.48
	Sesquioxide of iron	0.24
	Alumina	1.72
	Carbonate of lime	2.54
	— of magnesia	2.20
	Phosphoric acid	Traces
	Silica	3.02
Undecomposed by Hydrochloric acid 85.33 per cent.	Sesquioxide of iron	0.12
	Alumina	1.01
	Magnesia	1.00
	Silica	83.20
		99.48

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$	P_2O_5	SiO_2
2.48	0.36	2.73	2.54	2.20	Traces	85.23

Loss by Ignition
1.85 = 99.48.

Between this and the following analysis there is a slight difference; the sample from Station 267 was however brought up from a greater depth.

Station 267.

Lat. 71° 42′ N., long. 37° 1′ E.; 148 fathoms (271 metres); bottom-temperature —1.4°. A porous, greenish-grey clay containing a few pebbles (the largest weighing 0.5gr) of sandstone and argillaceous schist. The dredge brought up at this Station numerous stones and pebbles, consisting of hard slate, quartz-schist, dark-grey sandstone, red granite, dark argillaceous schist, also fragments of tuff (?), chocolate-brown in colour, and of a dark fluted stone, as also of a stone containing nodules of pyrites.

Specific gravity of the clay 2.59.

	Glødningstab	5.49
Dekomponeret af Saltsyre 9.83 pCt.	Jernoxydul	2.05
	Jernoxyd	1.00
	Lerjord	0.25
	Kalk	0.20
	Magnesia	1.49
	Kulsur Kalk	0.50
	Fosforsyre	Spor
	Kiselsyre	4.34
Udekomponeret af Saltsyre 83.28 pCt.	Jernoxyd	1.97
	Lerjord	9.33
	Magnesia	1.42
	Kiselsyre	70.56
	Sum	98.60

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
2.05	2.97	9.58	0.20	2.91	0.50	Spor	74.90

Glødn.tab	Sum
5.49	98.60

Bundprøven fra Station 267 har ikke ligesom den foregaaende undergaaet nogen Forandring ved at henligge i Luften; ved to Bestemmelser af dens Jernoxydul- og Jernoxydmængde med længere Tids Mellemrum er jeg kommet til de samme Resultater. Forholdet mellem Oxyderne var i begge Tilfælde 0.49. At Glødningstabet ved den sidste Bundprøve er betydelig høiere end ved den første, kan maaske være begrundet af en større Rigdom paa organiske Stoffe. Denne er muligens ogsaa forenet med en større Stabilitet ligeoverfor Luftens Paavirkning (?). Begge Bundprøver udviklede ved Ophedning en stærk ammoniakalsk og empyrevmatisk Lugt.

Foruden de ovenanførte Analyser har jeg i Rhabdammina-Leret udført en Del Kalk- og Jernbestemmelser, der vil tjene til Oplysning om dets Dyreliv og eiendommelige Oxydationsforhold. Mængden af den kulsure Kalk er fundet med Johnsons Apparat; Jernoxydul og Jernoxyd bestemt ved Titrering med Kamæleon og undersvovlsyrligt Natron.

Som det vil sees, er Kalkgehalten overordentlig ringe paa alle de Stationer, som ligger østenfor Beeren Eiland og søndenfor denne Ø's Breddegrad. Nogen tilsvarende Fattigdom findes neppe i Nordhavets øvrige Sedimenter eller er ialfald ikke paa saa store Strækninger udbredt med nogen lignende Regelmæssighed. Den samme Mangel paa kulsur Kalk har jeg fundet ved med Saltsyre at forsøge de øvrige Bundprøver, der er indsamlede fra denne Egn af Havbunden. Overalt viser sig kun en ganske ringe Kulsyreudvikling.

Paa Station 326, der ligger i det lille Parti af Rhabdammina-Leret, som paa Kartet er antegnet mellem Beeren

	Loss by ignition	5.49
Decomposed by Hydrochloric acid 9.83 pCt.	Protoxide of iron	2.05
	Sesquioxide of iron	1.00
	Alumina	0.25
	Lime	0.20
	Magnesia	1.49
	Carbonate of lime	0.50
	Phosphoric acid	Traces
	Silica	4.34
Undecomposed by Hydrochloric acid 83.28 pCt.	Sesquioxide of iron	1.97
	Alumina	9.33
	Magnesia	1.42
	Silica	70.56
		98.60

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
2.05	2.97	9.58	0.20	2.91	0.50	Traces	74.90

Loss by Ignition
5.49 = 98.60

Unlike the foregoing, the sample from Station 267 did not undergo any visible or substantial change on being exposed to the air. Two determinations of the protoxide and sesquioxide of iron, performed with a considerable interval between, gave the same results. The ratio of the oxides was in each case 0.49. That the loss by ignition on determining the constituents of the latter sample should have been considerably in excess of that resulting from the analysis of the former, from Station 264, may perhaps be ascribed to a greater abundance of organic remains, which in turn will possibly account for the greater stability exhibited in withstanding the influence of atmospheric air (?). Both samples emitted on exposure to heat a strong ammoniacal and empryeumatic odour.

Exclusive of the above-mentioned analyses, I have performed in Rhabdammina clay divers determinations of lime and iron, which will serve to throw light on the organisms present in that deposit and the characteristic results of its oxidation. The amount of carbonate of lime was found with Johnson's apparatus, that of protoxide and sesquioxide of iron by titration with permanganate of manganese and hyposulfite of soda.

As will be seen from the Table, the proportion of lime was remarkably small in all the samples collected at Stations east and south of Beeren Eiland. A corresponding characteristic as regards this constituent will hardly be found to occur in any other of the North-Atlantic deposits, at least with equal uniformity throughout such extensive tracts. The same comparative absence of carbonate of lime I have determined, by treating with hydrochloric acid, in the remaining samples brought up from that tract of the ocean-bed. The quantity of carbonic acid thus generated was without exception very trifling.

At Station 326, located between Beeren Eiland and Spitzbergen, above the small section of the sea-bed shown

Eiland og Spidsbergen, er Kalkgehalten fundet betydelig høiere end i den sydvestligere Del af Østhavet.

in the map to have a surface-layer of Rhabdammina clay, the sample was found to contain a proportion of lime considerably in excess of that distinguishing the same kind of deposit from the south-western tract of the East Sea.

Station.	Nordlig Bredde. (N. Latitude.)	Ø. Længde fra Greenw. (Long. from Greenw. E.)	Dybde i engl. Favne. (Depth in Eng. Fath.)	$CaCO_3$	Fe_2O_3	FeO	Samlet Fe (Total Fe.)	Fe_2O_3: FeO	Anmærkninger. (Remarks.)
264	70° 56′	35° 37′	86	2.54	0.24	2.48	2.09	0.09	
266	71 27	35 39	130	Spor (Traces.)	2.57	2.45	3.70	1.02	Underliggende Lag mørkgraat, fast Ler[1]. *On an Under Layer of compact, dark-grey Clay.*[1]
267	71 42	37 1	148	0.50	1.00	2.05	2.29	0.49	
268	71 36	36 18	130	0.48	1.21	1.52	2.03	0.78	
270	72 27	35 1	136	Spor (Traces.)	1.51	1.71	2.39	0.88	
275	74 8	31 12	147	1.59	1.32	3.23	3.43	0.41	
326	75 32	17 50	123	16.82	1.19	2.51	2.78	0.47	

Dette er rimeligvis at betragte som en Tilfældighed, da alle de nærliggende Bundprøver (Station 324, 326 og 327) kun bruser svagt for Syrer.

Med Hensyn til det grønlige Lers Oxydationsgrad viser det sig, at det gjennemgaaende indeholder betydelig mere Jernoxydul i Forhold til Oxydet end de graa og de brune Sedimenter. Her maa det tillige bemærkes, at hvor vi ellers i Nordhavet træffer et Ler med lignende Blandingsforhold eller med en tilsvarende høi Kiselsyregehalt, er dette i Almindelighed af en brunlig Farve eller altsaa stærkere oxyderet, men forekommer tillige meget sjelden paa saa ringe Dyb som Rhabdammina-Leret.

Nordhavets østlige Del er imidlertid ogsaa en Egn for sig selv, hvis Særegenheder med Hensyn til Bundens Formationer vanskeliggjør enhver Sammenligning med dets øvrige Partier.

Medens vi langs Norges Vestkyst finder en fra Landet af mere eller mindre jevnt skraanende Havbund, har Østhavet selv paa de fjerneste Punkter omtrent den samme Dybde som lige i Nærheden af Kysterne.

Særegne Betingelser kan saaledes være givne for Sedimenternes og Dyrelivets Fordeling i denne Egn af Havet, hvor Dybderne paa mange Steder — i lang Afstand fra

[1] Dette gaar altsaa ikke ind under Benævnelsen Rhabdammina-Ler, men er ogsaa optaget i Tabellen paa Side 43 blandt Prøverne af det graa Ler.

This, however, is probably a casual occurrence, all the samples collected in adjacent localities (Stat. 324, 326, and 327) effervescing but slightly with acids.

With regard to the degree of oxidation distinguishing Rhabdammina clay, that greenish deposit generally contains much more of the protoxide in proportion to the sesquioxide of iron than do any of the grey or brown clays. Here I must also observe, that wheresoever else on the bed of the North Atlantic we meet with a clay similar in composition, or characterized by an equal amount of silica it will, as a rule, being more highly oxidized, have a brownish colour, but rarely occur at so moderate a depth as Rhabdammina clay.

Meanwhile, the eastern section of the North Atlantic constitutes as regards the nature of the deposits distributed over its bed an exceptional locality, whose phenomenal characteristics well-nigh preclude comparison with the other parts of that ocean tract.

Along the west coast of Norway the bottom shelves more or less gradually from the land, whereas in the East Sea the depth even at the most distant points is almost the same as in close proximity to the shore.

Hence, peculiar conditions may determine the distribution of both sedimentary deposit and animal life in this tract of the ocean, where the depth in numerous localities

[1] This part of the sample, which accordingly is not regarded as Rhabdammina clay, will be found in the Table given on page 43 among the samples of grey clay.

Kysten — ikke er større, end at vi i Overensstemmelse med tidligere Erfaringer kan tænke os, at Bølgernes Virkninger forplanter sig helt ned til Bunden.

I Overensstemmelse med de foregaaende Analyser synes det rimeligt at antage, at Rhabdammina-Leret — saaledes som vi finder det paa de østligste Stationer — maa have sin Oprindelse fra stærkt kvartsholdige Bergarter. For at finde saadanne behøver vi ikke at lede længe i de omgivende Lande; vi møder mægtige Sandstenlag paa Nordkysten af Norge, paa Beeren Eiland og Spidsbergen, ligesom ogsaa talrige Brudstykker af den samme Bergart blev fundne ved de fleste Dybdemaalinger og Skrabninger i Østhavet.

Men selv om vi med nogen Grad af Sandsynlighed kan tænke os, at denne Bergart har været den oprindelige Kilde for Dannelsen af Rhabdammina-Leret, saaledes som vi finder det paa de tvende ovennævnte Stationer, bliver det imidlertid et andet og vanskeligere Spørgsmaal at afgjøre, fra hvilken Kant Materialet er hentet, og hvorledes dette er blevet fordelt over den jevne og grunde Havbund.

Jeg skal her blot indskrænke mig til at nævne, at den omtalte lille Ø Beeren Eiland har særegne Betingelser for at kunne forsyne den nærliggende Havbund med stadig nye Bidrag til dens Afleiringer. Beeren Eiland har allerede i Løbet af en Menneskealder undergaaet betydelige Forandringer ved Isens og Bølgernes ødelæggende Virkninger. De løse itufrosne Bergslag, hvoraf Øen tildels bestaar, ligger ved Kysterne blottede for Havet, hvis Kraft her ikke bliver afdæmpet ved Holmer eller Skjær. Geologen Prof. Keilhau[1] giver i sin Beskrivelse af denne Ø følgende Skildring af, hvorledes Ødelæggelsen foregaar: "Ved saadanne vertikale Revner og ved de ydre Stykkers derpaa følgende Fraløsning gaar Øen lidt efter lidt sin fuldkomne Forsvinden imøde; allerede i Mands Minde er Kysternes Forandring mærkelig, og at slutte efter de ældste Erfaringer, maa allerede betydelige Stykker være undergangne".

Vi maa saaledes være berettigede til at formode, at Beeren Eiland stadig kan give Anledning til sedimentære *Ny*dannelser. Hvis Rhabdammina-Leret kan henregnes blandt saadanne, eller hvis det altsaa er et Depositum af senere Oprindelse end Nordhavets øvrige Sedimenter, kunde dette maaske være en Grund for den mindre oxyderte Tilstand, hvori det befinder sig.

Hvor vi i den vestlige Del af Nordhavet træffer et lignende porøst og stærkt sandholdigt Ler, er dette som oftest af en brun Farve, eller altsaa stærkere oxyderet. Man kunde altsaa tænke sig, at Slammets Oxydationsgrad var afhængig af den Tid, i hvilken det har befundet sig i Havet. Denne Antagelse bestyrkes, naar man ser hen til

[1] Reise til Vest- og Østfinmarken samt til Beeren Eiland og Spidsbergen.

— at a considerable distance from the coast — is not greater than will, we know, in conformity with experience, admit of the influence of the waves being transmitted from the surface to the bottom.

From the results of the foregoing analyses, it would appear that the origin of Rhabdammina clay, as that deposit occurs in the most easterly localities of the North Atlantic, may be traced to the disintegration of quarzitic rocks, — an assumption borne out by the geological character of the surrounding countries. Along the north coast of Norway, and on Beeren Eiland and Spitzbergen, we meet with vast masses of sandstone; and numerous fragments of that rock came up when sounding and dredging in the East Sea.

But even admitting that disintegrated sandstone has chiefly contributed to the formation of Rhabdammina clay as found at the two above-mentioned Stations, another and more difficult question remains to decide from what quarter the siliceous particles are derived, and how they are distributed over the level and shallow bottom.

On this head I shall merely observe here, that Beeren Eiland has peculiar facilities for constantly furnishing the adjacent portions of the sea-bed with the material composing their surface-layer of deposit. Within the memory of man, the combined action of the waves and glaciers have caused that island to undergo very considerable changes. The porous, frost-riven rocks of which this island in great part consists, are everywhere on the coast exposed to the full sweep of the ocean, no islets or skerries being here to break its force. The following extract from Professor Keilhau's description of Beeren Eiland[1] will show in what manner the work of destruction is proceeding: — "From the repeated occurrence of such vertical fissures and the subsequent dislocation of the outer fragments, the slow but total demolition of the island may be surely foreseen; even within the memory of man, a remarkable change has taken place in the coastal outline, and to judge from the oldest accounts considerable portions of the island must have already disappeared."

We have accordingly every reason to assume, that Beeren Eiland, so long as it exists, will still continue the source of sedimentary *new* formations. Now, regarding Rhabdammina clay as one of such layers, and therefore as of later origin than any other of the deposits distributed over the bed of the North-Atlantic, this may possibly serve to account for the low degree of oxidation by which that substance is distinguished.

A porous and highly sabulous clay is also met with in the western tract of the North Atlantic, but its colour is generally brown, indicating a more advanced stage of oxidation. We might therefore not unreasonably infer that the greater or less extent to which a deposit is oxidized mainly depends on the length of the period during which it has

[1] Reise til Vest- og Østfinmarken samt til Beeren Eiland og Spitzbergen.

det — rigtignok enestaaende — Tilfælde, i hvilket jeg har paavist en Oxydation af Bundprøven ved dens Henliggen i Luften. En saadan Forandring skulde altsaa foregaa med stor Langsomhed i Havet.

Jeg vil imidlertid langtfra paastaa, at den ovenstaaende Forklaring er den rigtige; jeg indrømmer, at den staar paa meget svage Fødder, og har derfor blot fremsat den som en Gisning, for at henlede Opmærksomheden paa Slamarternes eiendommelige Oxydationsforhold. Talrige andre Omstændigheder maa ogsaa tages i Betragtning ved Afgjørelsen af dette Spørgsmaal. Saaledes er det f. Ex. utvivlsomt, at de i Slammet forekommende Dyr bidrager til dets Oxydation. Især finder man ofte en Udskillelse af rødt Jernoxyd paa de Punkter af Leret, hvor Annelider har gravet sig Gange. Mange Foraminiferer virker i den samme Retning, idet de danner sig stærkt jernoxydholdige Skaller. Som forud omtalt er Rhabdammina-Leret meget fattigt paa Dyrelevninger.

En af de Stene, der blev fundne i Østhavet paa Stat. 267, har jeg nærmere undersøgt. Det var en finkornig, blaagraa Sandsten med stærkt kalkholdigt Bindemiddel (Kalksandsten). I det saltsure Udtræk af denne Sten — tilberedt paa samme Maade som i Bundprøverne — fandtes:

1.38 pCt. FeO og 0.59 pCt. Fe_2O_3.

Altsaa et lignende Forhold som i Rhabdammina-Leret.

I Overensstemmelse med hvad der er sagt under Beskrivelsen af det graa Ler, vil det være indlysende, at vi ikke med Nøiagtighed kan bestemme Rhabdammina-Lerets sydlige og vestlige Grændser, da vi mangler de nødvendige Observationer fra denne Del af Havet. Den sidste hollandske Expedition i 1878 har foretaget endel Dybdemaalinger i Retningen Vardø—Beeren Eiland, men Bundens Beskaffenhed er ved denne Anledning ikke blevet nærmere undersøgt.

De paa Side 40 omtalte uregelmæssige Afleiringer af brunt Sand og Sandler, der forekommer i Syd og Sydvest for Beeren Eiland, kan maaske ogsaa med Hensyn til sin Dannelse staa i Forbindelse med denne Ø.

Brunt Ler.

(Overgangsler og Biloculinler).

Ved Dybder, der er større end 500 Favne, finder man i Almindelighed Bunden bedækket af et bruntfarvet Sediment. Dette er i Begyndelsen af sin Optræden mindre fint og ensartet (sandholdigt) og af en mere graalig Farve end længere ud i Havet, hvor Biloculinerne forekommer. De Grændser, indenfor hvilke disse Foraminiferer med Regelmæssighed og i større Antal optræder, ligger i Almindelighed et godt Stykke indenfor det brune Lers egentlige Omraade. Den mere eller mindre brede Strimmel af brunt

been lying at the bottom of the sea. Nay, this view will appear still more plausible if we call to mind the case — isolated, it is true — in which I succeeded in determining the oxidation of oceanic deposit after exposure to atmospheric influence. This change in chemical composition must accordingly be very slow on the sea-bed.

Meanwhile, I would by no means venture to imply that the above explanation is correct; it has weak points, I freely admit, and has therefore been advanced suggestively, with the object of drawing attention to the characteristic results of oxidation in the various deposits. Many other conditions must be taken into account ere this question can be decided. Thus, for instance, the living organisms that occur in the deposit contribute beyond a doubt in some measure to its oxidation. In particular, red oxide of iron is frequently found deposited on the clay where Annelids have excavated their passages; and numerous species of Foraminifera operate with a like result, their shells being rich in oxide of iron. As previously stated, Rhabdammina clay contains very few animal remains.

One of the mineral fragments brought up in the East Sea, at Station 267, I have submitted to analysis. It was a piece of finely granulated, bluish-grey sandstone, with a large admixture of cementitious lime (calcareous sandstone). In the hydrochloric acid decoction of this mineral substance — prepared precisely as was that for analysing the samples of the bottom — I determined: —

1.38 per cent of FeO and 0.59 per cent of Fe_2O_3, accordingly the same proportion as in Rhabdammina clay.

From what has been stated in the description of the green clay, it is obviously impossible to define with accuracy the southern and western limits of the Rhabdammina clay, the necessary observations not having been taken in that part of the North Atlantic. The last Dutch Expedition, however, took a series of soundings between Vardø and Beeren Eiland, but those explorers did not pay any particular attention to the nature of the sea-bed.

The exceptional surface-layers of brown sand and sabulous clay mentioned on page 40, and occurring south and south-west of Beeren Eiland, may possibly as regards their formation be connected with that island.

Brown Clay.

(Transition Clay and Biloculina Clay.)

At depths exceeding 500 fathoms, a brown-coloured clay is generally found to constitute the surface-layer of the bottom. Where it first occurs, this deposit is coarser and less homogeneous in substance (sabulous), and of a greyer shade than farther from the coast, where its chief characteristic consists in the presence of *Biloculinæ*. The limits for the occurrence of these Foraminifera as a constant feature and in greater numbers, reach as a rule a good distance within the true province

Ler, som ikke er noget almindeligt Forekomststed for hine Foraminiferer, eller som altsaa ligger imellem Kystleret og det saakaldte Biloculinler, har jeg paa Kartet afgrændset for sig selv under Navn af Overgangsler.

Det forholder sig imidlertid ikke saaledes, at det graa Ler ophører, hvor det brune begynder at forekomme. Tvertimod finder vi ofte, at det førstnævnte vedbliver at udgjøre det underste Lag af Bundprøven selv indenfor det egentlige Biloculinlers Omraade. Det viser sig saaledes, at det brune Sediment kun meget langsomt tiltager i Mægtighed. Paa flere af Expeditionens Tversnit fandtes det graa Ler som en væsentlig Del af Bundprøven indtil en Afstand af ca. 15 Mile fra den første Station, hvor det brune Ler havde begyndt at vise sig. Et Par af de Bundprøver, der var optagne paa meget store Dyb (over 1700 Favne), bestod udelukkende af graat Ler og indeholdt kun ganske smaa Mængder af det brune. Disse Observationer tyder paa, at Biloculinleret er en Dannelse af ringe Mægtighed, hvilende paa et underliggende Lag af graat Ler. Dette stadfæstes end yderligere ved Skrabningerne, under hvilke en Mængde graat Ler optoges paa de største Dybder.

I Overgangsleret forekommer Biloculiner og de øvrige Dybvands-Foraminiferer blot spredt og enkeltvis. Skjønt det derfor i Almindelighed kun bruser svagt for Syrer, hænder det dog stundom, at Kalkgehalten er temmelig betydelig, selv om ingen Skaller kan iagttages hverken i det oprindelige Ler eller i dets Residuum efter Slemning.

Indenfor de Grændser, hvor de ovennævnte Foraminiferer optræder med Regelmæssighed og i større Antal, er det brune Ler meget fint og ensartet og synes selv under en stærk Lupe kun at bestaa af amorfe Partikler.

Biloculinlerets brune Farve kan være mere eller mindre udpræget. Nogle Bundprøver er lyse gulbrune, andre mørkbrune, i fugtig Tilstand næsten chokoladefarvede. Talrige smaa, hvide Foraminiferer bidrager naturligvis til at give Leret en lysere Farve.

Ved Slemning af Biloculinleret erholder man et større eller mindre Residuum, der væsentlig bestaar af Foraminiferer af forskjellig Størrelse, Form og Farve. Under Lupen viser det sig dog, at nogle yderst smaa, runde Kalkskaller med et tydeligt Kammersystem er langt overveiende i Antal fremfor de øvrige. Professor G. O. Sars har været af den Godhed at bestemme disse Dyr for mig. Han har fundet, at de hører til de meget bekjendte "Globigeriner", men at de er meget mindre udviklede med Hensyn til Størrelse end de, der forekommer i de sydligere Have.

Da disse Dyr overalt i Nordhavet er Biloculinernes uadskillelige Ledsagere, kunde maaske det her omhandlede Sediment ogsaa gaa ind under Navnet "Globigerinler", en Betegnelse, der er blevet benyttet i de britiske Expeditioners Rapporter. Ifølge John Murray skal dette Sediment, hvis mest typiske Eiendommelighed er dets Rigdom paa Globigeriner, forekomme i stor Udstrækning i det af Challengerexpeditionen beseilede Hav, hvor det er fundet paa de fleste

of the brown clay. The strip of brown clay, varying in width, where that deposit does not regularly contain *Biloculinæ,* I have marked off on the map as a separate formation, under the name of transition clay.

Meanwhile, it is by no means to be supposed that the grey clay suddenly terminates where the brown begins to occur. On the contrary, the former deposit was frequently found to constitute the under layer of samples brought up from within the limits of the true biloculina formation. Vertically, therefore, the increase of the brown deposit is very slow. In several of the localities of the tract explored, the grey clay was found to constitute a large part of every sample, within a distance of 15 geographical miles from the first Station at which the brown clay occurred. One or two samples, obtained from great depths (upwards of 1700 fathoms), consisted almost exclusively of grey clay, the admixture of brown deposit being very small. From these data, Biloculina clay is shown to be a deposit of trifling vertical extent, with an underlying layer of grey clay. Moreover, a good deal of grey clay came up in the dredge from the greatest depths.

In the transition clay, *Biloculinæ* and the other deep-sea species of Foraminifera occur but occasionally, and scattered. Hence, though as a rule, therefore, that deposit effervesces very slightly with acids, the proportion of lime is sometimes considerable, even when no calcareous shells can be detected either in the clay itself or the residue left on washing it.

When regularly characterised by the presence of the above-mentioned Foraminifera in considerable numbers, the brown clay is an exceedingly fine and homogeneous deposit, and would appear, even if examined under a powerful magnifier, to consist of amorphous matter.

The brown colour of Biloculina clay varies considerably in depth and distinctness. Some of the samples were light yellowish-brown, others dark-brown, — nay almost of a chocolate shade in a damp state. Numbers of minute white Foraminifera naturally contribute to give the clay a whiter tint.

On washing Biloculina clay, there is a greater or less residue, which chiefly consists of divers species of Foraminifera, varying in magnitude, form, and colour. With the aid of a lens, minute, round, calcareous shells having a distinct system of chambers are found to exceed by far in number the other animal remains. Professor G. O. Sars has had the kindness to determine these animals. He found them to be known *Globigerinæ,* though much less developed in point of size than the species which occur in the Southern Seas.

These animals invariably accompanying *Biloculinæ* in the North Atlantic, the brown deposit here treated of might be also termed "Globigerina clay," a designation adopted in the Reports from the various British Expeditions. According to Mr. John Murray, this sedimentary substance, whose chief typical characteristic consists in the presence of great numbers of *Globigerinæ,* occurs extensively throughout the tracts of ocean investigated on the "Challenger"

Dybder imellem 1000 og 2500 Favne. Hvad der imidlertid ved denne Anledning er blevet kaldt "Globigerina-Ooze", omfatter kun de Slamarter, som for en væsentlig Del bestaar af hine Foraminiferer og altsaa har en meget høi Kalkgehalt. Biloculinleret indeholder derimod paa mange Steder — saaledes som de senere Analyser vil vise — kun en ringe Mængde Kalkskaller i Forhold til sine øvrige mineralske Bestanddele. Lerets Forraad paa Globigeriner differerer nemlig meget i de forskjellige Dele af Nordhavet. Biloculinerne synes derimod at være temmelig jevnt fordelte over Havbunden, men da de i Almindelighed forekommer i ringe Antal (sjelden ser man mere end 2 Biloculiner paa en Kvadratcentimeter af den tørrede Bundprøve) kan de ikke i nogen betydelig Grad bidrage til Lerets Kalkgehalt. Paa Grund af disse Dyrs regelmæssige Forekomst og Udbredelse i Dybvandsslammet synes det mig, at Navnet "Biloculinler" er heldig valgt.

For at kunne gjøre os en Ide om, hvilken Betydning hine Foraminiferer har for Dannelsen af de Afleiringer, i hvilke de forekommer, maa vi tage deres zoologiske Forhold i Betragtning.

Med Hensyn til Globigerinerne er Zoologerne i Uenighed om, hvorvidt de blot er pelagiske Dyr, eller om de ogsaa formaar at leve paa Havbunden[1]. De bekjendte britiske Naturforskere Sir Wyville Thomson, Jeffreys og John Murray er af den Mening, at Globigerinerne blot lever som fritsvømmende Dyr i Havet, og at de først efter sin Død synker tilbunds. Dr. Carpenter forfægter imidlertid en anden Anskuelse, hvori ogsaa Prof. Sars er enig med ham, nemlig at Globigerinerne i sin første Levetid er pelagiske, men tilbringer den sidste Del af sin Tilværelse paa Havbunden.

De øvrige i Slammet forekommende Foraminiferer har man ikke fundet i de øvreliggende Vandlag, og de synes derfor at være henviste til blot at leve paa Bunden. Blandt de almindeligste af disse maa nævnes Slægten *Lituola* med kuglerunde, af Jernfosfat bruntfarvede Skaller, og *Nonionina,* hvis uorganiske Del bestaar af ren kulsur Kalk. Forøvrigt findes der i Leret ogsaa andre Foraminiferer, der danner sine Skaller paa væsentlig mekanisk Vis ved Sammenkitning af Lerets forskjellige Partikler.

Levninger af kiselpantsrede Dyr er ikke synderlig udbredte i Biloculinleret. Under Mikroskopet ser man i de fleste Prøver enkelte smaa fine Spikuler af Svampe, men disse forekommer dog i meget større Maalestok i

[1] Med Hensyn til den zoologiske Literatur om dette Emne kan nævnes følgende Afhandlinger: Dr. Wallich: "The North-Atlantic seabed." Preliminary Report by Dr. Carpenter. (From the Proceedings of the Royal Society No. 107, 1868). "Deep-sea exploration," a lecture by J. Gwyn Jeffreys.

Expedition, having been met with almost everywhere in depths ranging from 1000 to 2500 fathoms. Meanwhile, the surface-layers to which the name of "globigerina ooze" has been given by British naturalists, comprises only such deposits as consist in great part of those Foraminifera and are accordingly distinguished by a very large proportion of lime. Biloculina clay, on the other hand, contains in many localities — as will appear from the results of analyses subsequently given — very few calcareous shells compared to its other mineral constituents. Thus, the number of *Globigerinæ* in this clay from the different parts of the North Atlantic varies considerably, whereas the distribution of Biloculinæ would appear to be comparatively uniform; but these animals occurring as a rule sparingly (more than 2 *Biloculinæ* are seldom observed to a square centimetre of dried deposit), they cannot of course materially contribute to the proportion of lime in the clay. The uniformity of occurrence characterising the distribution of these animals throughout the deep-sea deposit of the North Atlantic, naturally suggested "Biloculina clay" as an appropriate name.

To form a just idea of the extent to which these Foraminifera contribute to the formation of the deposits in which they occur, we must also investigate their zoological conditions.

With regard to *Globigerinæ,* zoologists do not agree, some regarding those Foraminifera as strictly pelagic and others as animals whose habitat is the bed of the sea.[1] The British naturalists Sir Wyville Thomson, J. Gwyn Jeffreys, and John Murray, are of opinion that *Globigerinæ* during life swim freely in the waters of the ocean and when dead sink to the bottom. Dr. Carpenter entertains a different view, shared by Professor G. O. Sars, according to which *Globigerinæ* are pelagic during the early stages of their existence but pass the remainder on the sea-bed.

The other species of Foraminifera present in deep-sea deposit have not been met with in the upper strata of the ocean, and would appear therefore exclusively to inhabit the bottom. Of these animals the genera most numerously represented are *Lituola,* with globular shells, brown in colour from the phosphate of iron they contain, and *Nonionina,* of which the inorganic part consists of pure carbonate of lime. For the rest, North-Atlantic deposit contains divers other Foraminifera, which build up their shells in greater part mechanically, by cementing together minute particles of the clay.

Siliceous remains of animals are not particularly abundant in Biloculina clay. Examined under the microscope, most of the samples were found to contain delicate spicules of sponges, but such constituents occur in far greater num-

[1] The following are some of the chief works in which this subject is treated: — Dr. Wallich: "The North-Atlantic Sea-Bed:" "Preliminary Report by Dr. Carpenter (From the Proceedings of the Royal Society, No. 107, 1868). "Deep-sea Exploration," a Lecture by J. Gwyn Jeffreys.

Overgangsleret, der ofte er saa gjennemvævet af disse fine Kiselnaale, at man ved at berøre den tørrede Bundprøve faar Huden fuld af dem.

Vi er berettigede til at antage, at Havets fysiske Forhold maa have en stor Betydning for Dyrelivets Udbredelse eller Fordeling over Havbunden; især gjælder dette om Globigerinerne, der som pelagiske Foraminiferer maa være udsatte for de forskjellige Strømningers Virkning — hvad enten de nu i død eller levende Tilstand synker ned i Slammet. Ved mine kemiske Undersøgelser af Biloculinleret har jeg, som senere skal sees, taget Hensyn til disse Spørgsmaal.

Betragter man forskjellige Prøver af Biloculinleret under Mikroskopet, vil man finde, at Blandingsdelenes Finhed ikke altid er den samme. Mangensteds kan man neppe selv med en stærk Forstørrelse adskille de enkelte Partikler, men i Almindelighed ser man dog en Del krystallinske Korn, der tildels er af forskjellig Farve. De fleste af disse er imidlertid farveløse og gjennemsigtige og synes for den største Del at bestaa af Kvarts. At dette Mineral kan udgjøre en væsentlig Bestanddel af Dybvandsslammet, har allerede Ehrenberg[1] paavist ved sine Undersøgelser af tre Prøver fra Atlanterhavets Bund (Dybde: 10,800, 12,000 og 12,900 Fod).

Slammets fineste krystallinske Partikler er i Almindelighed temmelig skarpkantede; grovere for det ubevæbnede Øie synlige Korn forekommer næsten aldrig i Biloculinleret, men er derimod ikke ualmindelige i Overgangsleret og har da som oftest en afrundet Form. I det sidstnævnte Ler ser man ofte talrige Glimmerblade; disse forekommer ogsaa i Biloculinleret, men er her saa yderst smaa, at de vanskelig kan opdages.

Pimpsten eller amorft, vulkansk Glas synes ikke at udgjøre nogen væsentlig Del af Biloculinlerets mikroskopiske Bestanddele. I 10—15 Prøver fra forskjellige Partier af Havbunden fandtes vulkansk Glas blot paa et Par Stationer. Nogle større Stykker (2 × 2 × 2 Cm.) blev optagne paa Station 40. Her gjordes forøvrigt et eiendommeligt Fund, der fortjener nærmere Omtale. Sammen med Pimpstenstykkerne fandtes nemlig i Skraben en Mængde faste Klumper eller Knoller, der var af forskjellig Udseende og Art, liggende aldeles for sig selv, ligesom Stene i Lermassen. De største af disse (6 × 6 × 6 Cm.) var af en meget forskjellig og uregelmæssig Form; den haarde og furede Overflade var tildels bedækket af et tyndt sort Lag, der væsentlig var dannet af Manganoxyder, medens det indvendige bestod af en brunrød, porøs Substans, der indeholdt en temmelig betydelig Mængde vulkansk Glas.

Disse Klumper var temmelig faste, men tillige meget sprøde og kunde med Lethed brydes istykker; de havde en

[1] Berliner acad. Berichte von 1854, S. 54, 236, 305, von 1855 S. 173. Nærmere beskrevet i "Microgeologie" von Ehrenberg. Leipzig 1854.

bers in transition clay, which is absolutely interwoven with these minute siliceous needles, so that, on touching the dried bottom-sample, the hand gets covered with them.

We have reason to believe that the physical conditions of the sea exert very considerable influence on the distribution of animal life over its bed; and in particular as regards *Globigerinæ,* which, as pelagic Foraminifera, must be exposed to the action of currents, in whichever state they reach the bottom — living or dead. To these questions, as will afterwards appear, I had due regard when analysing samples of Biloculina clay.

On examining under the microscope Biloculina clay from different localities, the fineness of its constituents is not always found to be the same. In some samples, even when highly magnified, it is hardly possible to distinguish the individual particles of which they consist: a number of crystalline granules, here and there varying in colour, may however be generally detected with a powerful lens; but the majority of such are colourless and translucent, consisting apparently in greater part of quartz, a mineral the occurrence of which as one of the principal constituents of deep-sea surface-layers has been already shown by Ehrenberg,[1] who submitted to analysis three samples of such deposit from the bed of the Atlantic, — depth, respectively 10,800, 12,000, and 12,900 feet.

The finest crystalline particles of deep-sea deposit are as a rule comparatively sharp-edged; coarser granules occur very rarely if ever in Biloculina clay, whereas in transition clay such particles, of a rounded form, are not infrequently met with. The latter deposit is often found to contain numerous laminæ of mica schist, which also occur in Biloculina clay, but so delicate and minute as to be with difficulty detected.

Pumice or scoriæ does not appear to be one of the chief microscopic constituents of Biloculina clay. Of 10 to 15 samples from different parts of the sea-bed, scoriæ occurred in one or two only. A few larger pieces (2 × 2 × 2 cm) came up at Station 40, where the deposit was found to be characterized by a peculiar feature, which I must not omit to record. Along with the fragments of pumice, but lying apart and imbedded like stones or pebbles in the clay, the dredge brought up a number of nodules or concretions, varying in character and appearance. The largest, measuring 6 × 6 × 6 cm, were very different and irregular in form; the hard, furrowed surface had in some a thin coating of black oxide of manganese, whereas the inner portion consisted of a brownish-red, vesicular substance, containing a considerable proportion of scoriæ.

These concretions are comparatively firm, but at the same time exceedingly brittle; their weight too is very

[1] Berliner acad. Berichte von 1854, pp. 54, 236, 305, von 1855 p. 173. The subject is treated more at large in "Microgeologie" von Ehrenberg. Leipzig 1854.

meget ubetydelig Vægt og flød (i tørret Tilstand) paa Vand ligesom Pimpsten.

Den indvendige røde Substans var at føle paa som meget fint Mel og smuldrede let hen ved Berøring. Den havde følgende Sammensætning:

Glødningstab	14.46
Jernoxyd	26.15
Lerjord	14.14
Magnesia	1.38
Kiselsyre	40.45
Sum	96.58[1]

Paa Grund af sin ujevne Form og ubetydelige Vægt havde disse Klumper ved det første Øiekast megen Lighed med Pimpstene, men den nærmere Undersøgelse viste dog, at de forøvrigt var meget forskjellige fra disse. Intet sammenhængende Kiselskelet kunde paavises, og hvad der ved første Blik kunde antages for Blærerum, befandtes ved Eftersyn kun at være Huller efter Annelider, der isærdeleshed paa Overfladen havde gravet sig talrige Gange. Den indre røde Substans bestod vistnok for en Del af amorft, vulkansk Glas, men dette forekom i friske Splinter eller Stykker af et lignende Udseende, som det af Vulkanerne udkastede Pimpstenspulver.

Jeg er dog tilbøielig til indtil videre at fastholde den Tanke, at disse Klumper kan have sin Oprindelse fra Pimpstene, der har gjennemgaaet betydelige Forandringer paa Havbunden, hvor de har virket som et Filtrum for det gjennemstrømmende Vand. Det kan muligens tjene til Oplysning om denne Vandets Bevægelse paa Havbunden, at alle Furer eller Revner i de ovennævnte Klumper var delvis fyldte med Skaller af Globigeriner.

Paa Stat. 40 fandtes som sagt ogsaa en Del Stykker af umiskjendelig Pimpsten, der imidlertid var af en meget løs og usammenhængende Konsistens.

Foruden de ovenomtalte Klumper optoges paa samme Sted ogsaa andre, der var mindre end hine og forøvrigt af et ganske forskjelligt Udseende. Nogle af disse bestod af en hvid Substans, der havde megen Lighed med Kaolin. En mikroskopisk Undersøgelse viste, at den indeholdt en Mængde Kiselskaller af Diatomeer. Andre havde Form af flade Stykker og bestod af et mørkgrønt, fint Ler med enkelte gulhvide Baand. Den fjerde og sidste Slags var dannet af en fin og fast, gulhvid Substans, der i Udseende nærmest kunde sammenlignes med haard, hvid Ost. I de to sidstnævnte Arter opdagede jeg under Mikroskopet nogle enkelte Diatomeer og blot faa Splinter af vulkansk Glas.

Det synes altsaa, som om vi her paa en af Expeditionens sydligste Stationer har fundet Dannelser af lignende Art som de, der omtales af John Murray i "Reports from the Challenger".

[1] Da denne røde Substans ogsaa indeholdt noget Mangan, der ikke blev bestemt, kan maaske Tabet ved Analysen hidrøre derfra.

trifling, and they float (in a dry state) on the surface of water, like pumice.

The red inner substance, which crumbled to the touch, became impalpable as the finest flour on being reduced to powder. Its chemical constituents were as follows: —

Loss by ignition	14.46
Oxide of iron	26.15
Alumina	14.14
Magnesia	1.38
Silicic acid	40.45
	96.58[1]

By reason of their irregular form and inconsiderable weight, these concretions had apparently much in common with pumice; but a closer examination showed them to be essentially different from that substance. No siliceous skeleton could be detected, and what at the first glance might have been taken for vesicular cavities, proved to be the work of Annelids, which, from the surface in particular, had excavated many of their passages. The red-coloured inner substance did not indeed partly consist of scoriæ, but this constituent occurred in the form of minute splinters or particles, similar in appearance to the pumice-powder ejected by volcanoes.

Meanwhile, I am most inclined to regard these concretions, till further light shall have been thrown on their phenomenal occurrence, as the product of pumice, which, from having acted as a percolating medium for water flowing over the sea-bed, has undergone partial transformation. As a feature in some measure perhaps explanatory of the conditions determining the motion of such water, I can add that all furrows and crevices in the said concretions contained shells of *Globigerinæ*.

At Station 40, as previously stated, the dredge brought up a few pieces of unmistakeable pumice, exceedingly porous however and friable.

Exclusive of the above-described concretions, others of a smaller size and widely different appearance came up in the same locality. Some of these consisted of a white substance presenting considerable resemblance to kaolin, which, on being examined under the microscope, was found to contain great numbers of the siliceous shells of Diatoms. Others were lamellar in form, and consisted of a fine dark-green clay marked with a few yellowish-white bands. A fourth kind — the last — were formed of a fine and firm yellowish-white substance, in appearance very like hard, white cheese. The two last-mentioned kinds of concretions exhibited under the microscope divers isolated shells of Diatoms and a very few splinters of scoriæ.

Hence it would appear that the Norwegian Expedition, at one of its most southerly observing-stations, met with formations similar to those described by Mr. John Murray in "Reports from the 'Challenger'."

[1] The red-coloured part of the concretions having also contained manganese, this constituent is possibly comprised in the loss resulting from the analysis.

Ved denne Expedition optoges nemlig fra Havbunden en Mængde Klumper og Knoller, hvoraf enkelte ifølge Beskrivelsen maa være af en lignende Art som de ovennævnte fra Station 40. Den betydelige Udfældning af Manganoxyder, der ved samme Anledning blev paavist i Havbundens Afleiringer, synes derimod ikke at have noget Sidestykke i det europæiske Nordhav.

On that British Expedition numerous nodules and concretions were brought up in divers localities from the bed of the sea, some of which, to judge from the description, must have been similar in character to those that came up on the Norwegian Expedition at Stat. 40. Meanwhile, the very considerable proportion of oxide of manganese determined as a constituent of the deposit in which the nodules lay imbedded, does not appear to accompany the occurrence of such concretions in the North Atlantic.

Jeg har forud omtalt, at det brune Ler kun synes at udgjøre et tyndt Lag paa Havbunden. Hvor denne begynder at skraane op mod Kystbankerne og nærme sig til det graa Lers Territorium, finder vi i Særdeleshed ofte i Bundprøven et underliggende Lag af det sidstnævnte Sediment. Nedover mod Dybet tiltager det brune Ler i Mægtighed, og indenfor Biloculinlerets Omraade finder vi de fleste Bundprøver helt igjennem ensartede. De enkelte Steder, hvor der ogsaa her findes tvende forskjellige Lag i Bundprøven og den Mængde af graat Ler, der optoges med Skraben eller Trawlen, viser at Biloculinleret er af en forskjellig, men i det Hele taget ringe Tykkelse. Paa den Del af Havbunden, der ligger omkring Stationerne 213, 214 og 215 paa et Dyb af over 1700 Favne synes Biloculinleret i Særdeleshed at være meget tyndt udbredt. Paa Stat. 215 udgjorde det graa Ler den overveiende Del af Bundprøven og paa Stat. 213 fandtes kun Spor af Biloculinler. Dette graa Underler er meget fint, ensartet og plastisk, og bliver efter Tørring meget fast og sammenhængende. Leret indeholder ingen Dyrelevninger og Kalkgehalten er kun ubetydelig. Under Mikroskopet viser det yderst smaa krystallinske Partikler (Kvarts?), der først træder tydelig frem ved en Forstørrelse af 500—600 Gange.

As previously stated, the brown clay would appear to constitute a comparatively thin surface-layer. Where the sea-bed, shelving up to the coastal banks, begins to approach the province of the grey clay, samples of the bottom have very frequently an under layer of that deposit. Downward, in the direction of the depths, the brown clay increases in vertical extent, and within the limits of Biloculina clay, most samples of the bottom are found to be homogeneous throughout. From the few samples which even here consisted of two different layers, together with the large quantity of grey clay brought up in the dredge or trawl, Biloculina clay is however clearly shown to be a deposit of trifling though variable extent in a vertical direction. Throughout the section of the sea-bed surrounding Stations 213, 214, and 215, at a depth of more than 1700 fathoms, Biloculina clay would in particular appear to be very thinly distributed. At Station 215, the sample consisted in greater part of grey clay, and in that brought up at Station 213, traces only of Biloculina clay were observed. This grey underlying clay is fine, homogeneous, and plastic, and becomes on being dried exceedingly firm and cohesive; it contains no animal remains and the amount of carbonate of lime is inconsiderable (1—2 per cent). With the aid of the microscope, minute crystalline particles (possibly quartz), may be detected, which do not become distinctly visible till magnified five or six hundred times.

De Bundprøver, der blot bestaar af Biloculinler, er i Almindelighed helt igjennem ensartede med Hensyn til Udseende og Foraminiferernes Skaller saa jevnt fordelte i Lermassen, at ethvert Stykke af denne omtrent viser den samme Kalkgehalt.

Paa enkelte Steder forekommer dog i selve Biloculinleret en Lagdannelse, der giver sig tilkjende derved, at Bundprøvens øverste Del bestaar af et brunt, fint Ler uden Kalkskaller, medens der under dette findes et porøst Ler med en Mængde Foraminiferer. Denne Lagdannelse er af en lignende Art som den, man erholder ved at slemme Biloculinleret ud i Vand og derpaa lade det afsætte sig. Ved denne Operation synker alle Kalkskaller tilligemed andre grovere Partikler tilbunds, medens man øverst faar et fint kalkfattigt Ler. Det synes rimeligt at antage, at en lignende Bundfælding allerede kan foregaa i Havet og bidrage til den ovenomtalte Lagdannelse, men i saa Fald maa man fristes til at spørge, hvorfor den ikke altid forekommer i Biloculinleret.

Vi mangler for Øieblikket Forudsætninger til at kunne besvare dette Spørgsmaal, thi hertil kræves Kundskab om

Samples of the bottom consisting exclusively of Biloculina clay, are as a rule uniform in appearance throughout, and the foraminiferous shells so regularly distributed in the deposit, that every part of it has well-nigh the same proportion of lime.

In certain localities, however, the surface-layer of Biloculina clay was found to be exceptional in formation: a fine brown clay without calcareous shells constituted the upper part of the sample, whereas the under layer consisted of a porous clay containing great numbers of Foraminifera. This formation is similar to that of the deposit left on washing Biloculina clay, during which operation the calcareous shells and other coarser particles sink to the bottom, leaving a fine clay, containing very little lime, as the upper layer. Some such precipitating process may not improbably be going on in the waters of the ocean and thus contribute to the formation described above; but if so, the question naturally arises why the latter is not an invariable characteristic of Biloculina clay.

For the full investigation of this subject we are at present in want of the requisite data, assuming as it does

forskjellige Forhold, der endnu er os fuldkommen ubekjendte. Vi har saaledes ingen Erfaring om de kvantitative og temporære Betingelser, der er givne for Globigerinernes Afleiring paa Havbunden. Lige saa lidt kan vi af de i Bundprøverne fundne Skaller af ikke-pelagiske Foraminiferer slutte os til, hvor stærkt de levende Dyr har været repræsenterede i Slammet, eller hvorlænge de døde Dyrs Skaller vil opbevares paa Havbunden — tvende Spørgsmaal, der vel maa have sin Betydning for Slammets mekaniske Afleiring. Det er dog rimeligt at antage, at lang Tid kræves, for at Søvandet skal kunne opløse disse Kalkskaller. Vi ved af tidligere Forsøg, at de paa Grund af sin Gehalt paa organiske Stoffe ikke forholder sig som ren kulsur Kalk ligeoverfor Opløsningsmidler, men at de angribes langt vanskeligere. Man har fremsat den Paastand, at den kulsure Kalk lettere opløses i Dybet paa Grund af den større Mængde Kulsyre, som her skulde findes i Søvandet. Hr. Tornøes Undersøgelser over Kulsyremængden i det af den norske Expedition beseilede Hav modbeviser imidlertid denne Antagelse. Han har fundet, at Søvandet overalt reagerer alkalisk og altsaa ikke kan indeholde nogen fri, men blot normalt- og surtbunden Kulsyre; Mængden af denne er imidlertid paa Dybet omtrent den samme som ved Overfladen. At Forholdet skulde være anderledes i de øvrige Dele af Oceanet synes ikke at have nogen Sandsynlighed for sig, naar man ser hen til de talrige Undersøgelser, der stadfæster Søvandets Ensartethed med Hensyn til dets øvrige Bestanddele. Søvandets opløsende Evne ligeoverfor den kulsure Kalk skyldes altsaa ikke dets Gehalt paa fri Kulsyre.

Den ovenomtalte Lagdannelse i Biloculinleret kan ogsaa tænkes fremkommet ved en Slemningsproces, hvis Vandets Strømninger paa Bunden er stærke nok til at sætte Slammets fine Partikler i Bevægelse. Dette Spørgsmaal er imidlertid lige saa ubesvaret som de foregaaende. Det fortjener imidlertid at nævnes, at alle de fra Bunden optagne Vandprøver altid var ganske klare og uden Spor af svævende Partikler.

Betragter vi paa Kartet den østlige Grændselinie for Biloculinleret, vil vi finde, at den i Almindelighed gaar imellem 900 og 1100 Favne. Imidlertid træffer vi dog paa flere Steder Biloculinleret paa mindre Dyb, ligesom det ogsaa hænder, at det først begynder at vise sig under 1100 Favne. Mellem 64° og 68° N. B. gaar Biloculinlerets vestlige Grændse op til et grundere Dyb end længere Nord. Paa Stationerne 54, 96 og 248 møder vi det saaledes allerede paa 600, 805 og 778 Favne. Udenom den sidstnævnte Station, der ligger omtrent 50 Mile fra Land, gjør Dybdekurverne for 800—1000 Favne en skarp Bøining (sml. Side 40) indover mod Kysten indtil en Afstand fra denne af ca. 30 Mile; paa denne Strækning ligger Grændsen for Biloculinleret imellem 700 og 800 Favne. Paa den brat skraanende Havbund udenfor Lofoten og Vesteraalen finder vi

an intimate acquaintance with divers conditions as yet wholly unknown. Thus, for instance, we have everything to learn respecting the causes that determine the quantitative and temporary distribution of *Globigerinæ* over the sea-bed. Nor can we from the proportion of non-pelagic foraminiferous shells infer how numerously the living animals were represented in the deposit or the length of the period during which their shells are preserved from decomposition at the bottom of the sea — questions which cannot but exert considerable influence when investigating the mechanical conditions that determine the character and extent of the deposit. One thing is however tolerably certain, that a long time must elapse ere the sea-water can dissolve those calcareous shells. As shown by experiment, they differ from pure carbonate of lime in yielding much more slowly to the action of solvents, by reason of their large proportion of organic substances. Some are disposed to maintain that carbonate of lime is more readily soluble in the depths of the ocean owing to the greater amount of carbonic acid which the water has been held to contain there. Mr. Tornøe, however, in his Memoir on the carbonic acid in the Seas explored by the Norwegian Expedition, has, I think, successfully refuted that assumption. Sea-water he invariably found to react as an alkali; and hence its carbonic acid cannot occur free, but must obviously be combined with oxygen; as regards the proportion of that constituent, it is about the same in the depths as at the surface, and the general uniformity in composition shown by numerous investigations to characterize sea-water, precludes the probability of any deviation in this respect occurring throughout the intermediate strata. The power possessed by sea-water of dissolving carbonate of lime cannot therefore lie in a greater or less proportion of free carbonic acid.

The exceptional formation mentioned above as distinguishing Biloculina clay in some localities, might also be ascribed to the action of bottom-currents, if sufficient to intermingle and keep in motion the fine particles of the deposit. But this, like the foregoing, is a question which for the present we cannot pretend to decide. Meanwhile, all samples of water brought up from the bottom were perfectly clear, without a trace of floating particles.

On referring to the map annexed to this Memoir, the eastern limit of Biloculina clay will be seen to lie at a depth ranging from 900 to 1100 fathoms. In several localities however Biloculina clay is met with nearer the surface, and on the other hand, in some places it does not begin to occur till the depth has reached 1100 fathoms. Between lat. 64° and 68° N., the western limit of the Biloculina clay extends over a shallower part of the sea-bed than farther north. Thus, for instance, at Stations 54, 96, and 248 it lies at a depth of 600, 805, and 778 fathoms. Without the last of these Stations (about 50 geographical miles from land), the curves of depth for 800 to 1000 fathoms (see page 40) make a sudden bend in the direction of the coast, which they approach within a distance of 30 geographical miles, and throughout this tract the

det imellem 900 og 1100 Favne. I den Bugt af Havbunden, der ligger Nord for Vesteraalen, optræder Biloculinleret først paa et Dyb af mere end 1200 Favne. Grændselinien herfra og nordover indtil den 80de Breddegrad ligger imellem 1000 og 1100 Favne. Paa det samme Dyb begynder Biloculinleret i den sydligere Del af Nordhavet, hvor dette grunder op mod Færø—Islandsbanken.

boundary for Biloculina clay follows a depth ranging from 700 to 800 fathoms. Over the rapidly shelving bottom off Lofoten and Vesteraalen, it extends between 900 and 1100 fathoms. In the bight of the sea-bed north of Vesteraalen the first Biloculina clay occurs at a depth of more than 1200 fathoms. The boundary-line extending from this locality northwards to the 80th parallel of latitude lies at a depth ranging from 1000 to 1100 fathoms. This is the depth at which Biloculina clay first occurs in the southern part of the North Atlantic, where its bed shoals up towards the Færoe-Iceland bank.

Jeg har tænkt mig, at den ovenstaaende Betragtning af Biloculinlerets Udbredelse maaske senere kan blive en Støtte ved det fremadskridende Studium af Expeditionens fysiske og zoologiske Materiale. Tildels med det samme Hensyn for Øiet, har jeg anlagt mine kemiske Undersøgelser af dette Sediment, til hvilke jeg nu vil gaa over.

The above elucidative remarks on the distribution of Biloculina clay, will, it is hoped, in some measure serve to facilitate the progressive working out of the large amount of physical and zoological material collected on the Norwegian Expedition. Moreover, my chemical investigation of that deposit, to the results of which I shall now pass on, has been modified with the same object in view.

Den kvalitative Undersøgelse af Biloculinleret viser, at det foruden Jern, Lerjord, Kalk, Magnesia, Kiselsyre og Spor af Fosforsyre indeholder smaa Mængder af Manganoxyder. De sidste forekommer dog ikke som synlige Bestanddele af Lermassen i Lighed med de smaa Korn eller Klumper, der saa ofte blev fundne ved Challenger-expeditionen, men synes at maatte være meget fint fordelte i Bundprøverne og udgjør i det Hele taget en saa ringe Del af deres Bestanddele, at de vanskeliggjør en kvantitativ Bestemmelse. Det er muligt, at Manganoxyderne kan bidrage til at give Leret en stærkere brun Farve. Ved Ophedning udvikler Biloculinleret en temmelig stærk empyreumatisk Lugt.

A qualitative analysis shows that Biloculina clay, along with iron, alumina, lime, magnesia, silica, and traces of phosphoric acid, also contains small quantities of oxide of manganese. The last of these constituents does not however occur in a visible form, as small granules or concretions, so frequently met with on the "Challenger" Expedition, but would appear to be most sparingly distributed throughout the deposit, of which it constitutes so small a proportion as hardly to admit of being quantitatively determined. Possibly, this oxide of manganese gives a darker colour to the deposit. On exposure to heat, Biloculina clay emits a pungent empyreumatic odour.

For den kemiske Undersøgelse af Biloculinleret har jeg først og fremst udvalgt mig en Del Hovedstationer fra forskjellige Punkter af Nordhavet og analyseret Bundprøverne fra disse fuldstændig med Hensyn til alle Bestanddele.

For my chemical examination of Biloculina clay I selected samples brought up at some of the principal observing-stations in different parts of the North Atlantic, submitting portions of the deposit to a rigorous general analysis embracing all its constituents.

I det følgende har jeg opstillet mine Analyser efter Numeret af de Stationer, hvor Bundprøverne er optagne. Bestemmelserne er udført efter den paa Side 36 beskrevne Methode.

The analyses are arranged according to the numbers of the Stations at which the samples of deposit were collected. The method of determination was that described on page 36.

Station 51.

N. B. 65° 53', V. L. 7° 18'. 1163 Favne (2127 Meter). — 1.1°. Lysbrunt Biloculinler.

	Glødningstab	2.71
Dekomponeret af Saltsyre 73.49 pCt.	Jernoxydul	1.14
	Jernoxyd	2.74
	Lerjord	6.49
	Magnesia	0.93
	Kulsur Kalk	52.82
	Fosforsyre	Spor
	Kiselsyre	9.37

Station 51.

Lat. 65° 53' N., long. 7° 18' W.; 1163 fathoms (2127 metres); bottom-temperature — 1.1°. Light-brown Biloculina clay.

	Loss by ignition	2.71
Decomposed by Hydrochloric acid 73.49 per cent.	Protoxide of iron	1.14
	Sesquioxide of iron	2.74
	Alumina	6.49
	Magnesia	0.93
	Carbonate of lime	52.82
	Phosphoric acid	Traces
	Silica	9.37

Udekomponeret af Saltsyre 23.29 pCt.	Jernoxyd	1.59
	Lerjord	4.52
	Kalk	1.03
	Magnesia	0.50
	Kiselsyre	15.65
	Sum	99.49

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.14	4.33	11.01	1.03	1.43	52.82	Spor	25.02

Glødn.tab	Sum
2.71	99.49

Stat on 52.

N. B. 65° 47'. V. L. 3° 7'. 1861 Favne (3403 Meter). — 1.3°. Lysbrunt Biloculinler. En Mængde Foraminiferer, væsentlig Globigeriner.

Biloculinerne i denne Bundprøve var meget store, indtil 2.2^{mm} i Diameter.

	Glødningstab . .	4.62
Dekomponeret af Saltsyre 61.35 pCt.	Jernoxydul . . .	0.88
	Jernoxyd	3.65
	Lerjord	3.38
	Kalk	2 52
	Magnesia	0.80
	Kulsur Kalk . .	45.80
	Fosforsyre . . .	Spor
	Kiselsyre	4.32

Udekomponeret af Saltsyre 33.91 pCt.	Jernoxyd	1.52
	Lerjord	6.62
	Magnesia	Spor
	Kiselsyre	25.77
	Sum	99.88

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
0.88	5.17	10.00	2.52	0.80	45.80	Spor	30.09

Glødn.tab	Sum
4.62	99.88

Station 178.

N. B. 69° 29', Ø. L. 12° 26'. 1578 Favne (2886 Meter). — 1.3°. Lysbrunt Biloculinler.

Undecomposed by Hydrochloric acid 23.29 per cent.	Sesquioxide of iron	1.59
	Alumina	4.52
	Lime	1.03
	Magnesia	0.50
	Silicic acid . . .	15.65
		99.49

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.14	4.33	11.01	1.03	1.43	58.82	Traces	25.02

Loss by Ignition
2.71 = 99.49.

Station 52.

Lat. 65° 47' N., long. 3° 7' W.: 1861 fathoms (3403 metres); bottom-temperature — 1.3°. Light-brown Biloculina clay containing a great many Foraminifera, chiefly *Globigerinæ*.

The *Biloculinæ* in this sample were very large, some measuring 2.2^{mm} in diameter.

	Loss by ignition .	4.62
Decomposed by Hydrochloric acid 61.35 per cent.	Protoxide of iron .	0.88
	Sesquioxide of iron	3.65
	Alumina	3.38
	Lime	2.52
	Magnesia	0.80
	Carbonate of lime.	45.80
	Phosphoric acid	Traces
	Silicic acid . . .	4.32

Undecomposed by Hydrochloric acid 33.91 per cent.	Sesquioxide of iron	1.52
	Alumina	6.62
	Magnesia . . .	Traces
	Silicic acid . . .	25.77
		99.88

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
0.88	5.17	10.00	2.52	0.80	45.80	Traces	30.09

Loss by Ignition
4.62 = 99.88.

Station 178.

Lat. 69° 29' N., long. 12° 26' E.; 1578 fathoms (2886 metres): bottom-temperature — 1.3°. Light-brown Biloculina clay.

	Glødningstab . .	4.95
Dekomponeret af Saltsyre 53.35 pCt.	Jernoxydul . . .	1.59
	Jernoxyd . : .	2.85
	Lerjord	5.84
	Kalk . . . . ;	0.21
	Magnesia . . .	2.40
	Kulsur Kalk . .	32.35
	Fosforsyre . . .	Spor
	Kiselsyre	8.01
Udekomponeret af Saltsyre		41.70
	Sum	100.00

Station 205.

N. B. 70° 51', Ø. L. 13° 3'. 1287 Favne (2354 Meter). — 1.2°. Lysbrunt Biloculinler. Gjennemsnitlig omtrent 2 Biloculiner paa hver Kvadratcentimeter af den tørrede Bundprøve. Talrige Globigeriner. Mange af Slægten *Lituola* og enkelte af *Nonionina*. Ingen Stene i Bundprøven.

	Glødningstab . .	6.06
Dekomponeret af Saltsyre 48.17 pCt.	Jernoxydul . . .	1.44
	Jernoxyd . . .	4.97
	Lerjord	4.08
	Kalk	3.84
	Magnesia . . .	2.82
	Kulsur Kalk . .	21.00
	Fosforsyre . . .	Spor
	Kiselsyre . . .	10.02
Udekomponeret af Saltsyre		45.77
	Sum	100.00

Station 214.

N. B. 70° 39', Ø. L. 0° 0', 1665 Favne (3045 Meter). — 1.2°. Mørkbrunt Biloculinler. (Den nederste Del af Bundprøven bestod af graat Ler). En liden Sten, der syntes at være et Stykke af en krystallinsk Skifer, veiende omtrent 0.3 Gr.

	Glødningstab . .	4.91
Dekomponeret af Saltsyre 52.54 pCt.	Jernoxydul . . .	1.61
	Jernoxyd . . .	4.05
	Lerjord	4.32
	Kalk	0.61
	Magnesia . . .	2.29
	Kulsur Kalk . .	29.93
	Fosforsyre . . .	Spor
	Kiselsyre . . .	9.73
Udekomponeret af Saltsyre 43.09 pCt.	Jernoxyd . . .	2.28
	Lerjord	8.53
	Magnesia . . .	0.94
	Kiselsyre . . .	31.34
	Sum	100.54

	Loss by ignition .	4.95
Decomposed by Hydrochloric acid 53.35 per cent.	Protoxide of iron	1.59
	Sesquioxide of iron	2.85
	Alumina . . .	5.84
	Lime	0.81
	Magnesia . . .	2.40
	Carbonate of lime	32.35
	Phosphoric acid	Traces
	Silica	8.01
Undecomposed by Hydrochloric acid		41.70
		100.00

Station 205.

Lat. 70° 51' N., long. 13° 3' E.; 1287 fathoms (2354 metres); bottom-temperature — 1.2°. Light-brown Biloculina clay containing: — *Biloculinæ*, on an average 2 in every square centimetre of the dried sample; numerous *Globigerinæ*, a good many of the genus *Lituola* and a few of the genus *Nonionina*; no pebbles.

	Loss by ignition .	6.06
Decomposed by Hydrochloric acid 48.17 per cent.	Protoxide of iron	1.44
	Sesquioxide of iron	4.97
	Alumina . . .	4.08
	Lime	3.84
	Magnesia . . .	2.82
	Carbonate of lime	21.00
	Phosphoric acid	Traces
	Silica	10.02
Undecomposed by Hydrochloric acid		45.77
		100 00

Station 214.

Lat. 70° 39' N., long. 0° 0' E.; 1665 fathoms (3045 metres); bottom-temperature — 1.2°. Dark-brown Biloculina clay (lower part of sample grey clay) containing a small mineral fragment, apparently crystalline schist, weighing 0.3gr.

	Loss by ignition .	4.91
Decomposed by Hydrochloric acid 52.54 per cent.	Protoxide of iron	1.61
	Sesquioxide of iron	4.05
	Alumina . . .	4.32
	Lime	0.61
	Magnesia . . .	2.29
	Carbonate of lime	29.93
	Phosphoric acid	Traces
	Silica	9.73
Undecomposed by Hydrochloric acid 43.09 per cent.	Oxide of iron . .	2.28
	Alumina . . .	8.53
	Magnesia . . .	0.94
	Silica	31.34
		100.54

Udekomponeret af Saltsyre 44.43 pCt.		
	Jernoxyd	3.29
	Lerjord	8.81
	Magnesia	Spor
	Kiselsyre (dek. og udek.)	32.33
	Sum	99.90

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
0.92	7.24	13.52	0.42	1.94	41.18	Spor	32.33

Glødn.tab	Sum
2.35	99.90

Station 295.

N. B. 71° 59′, Ø. L. 11° 40′. 1110 Favne (2030 Meter). — 1.3°. Lysbrunt Biloculinler. Ingen Stene. (Som det underste Lag af Bundprøven fandtes noget graat Ler). Mange Foraminiferer, men forholdsvis faa Globigeriner, væsentlig *Lituola* og *Nonionina*.

	Glødningstab	5.27
Dekomponeret af Saltsyre 52.79 pCt.	Jernoxydul	1.26
	Jernoxyd	3.57
	Lerjord	9.19
	Kalk	0.92
	Magnesia	0.88
	Kulsur Kalk	27.09
	Fosforsyre	Spor
	Kiselsyre	9.88
Udekomponeret af Saltsyre. 42.96 pCt.	Jernoxyd	1.91
	Lerjord	10.33
	Magnesia	0.80
	Kiselsyre	29.92
	Sum	101.02

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.26	5.48	19.52	0.92	1.68	27.09	Spor	39.80

Glødn.tab	Sum
5.27	101.02

Station 301.

N. B. 74° 1′, V. L. 1° 20′. 1684 Favne (3080 Meter). — 1.6°. Biloculinler, mørkere brunt end det foregaaende. (En ubetydelig Mængde graat Underler). Forholdsvis faa Foraminiferer.

Undecomposed by Hydrochloric acid 44.43 per cent.		
	Sesquioxide of iron	3.29
	Alumina	8.81
	Magnesia	Traces
	Silica (dec. and und.)	32.33
		99.90

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
0.92	7.24	13.52	0.42	1.94	41.18	Traces	32.33

Loss by Ignition
2.35 = 99.90.

Station 295.

Lat. 71° 59′ N., long. 11° 40′ E.; 1110 fathoms (2030 metres); bottom-temperature — 1.3°. Light-brown Biloculina clay (on a thin under layer of grey clay) containing a great many Foraminifera, but comparatively few *Globigerinæ*, belonging in greater part to the genera *Lituola* and *Nonionina*.

	Loss by ignition	5.27
Decomposed by Hydrochloric acid 52.79 per cent.	Protoxide of iron	1.26
	Sesquioxide of iron	3.57
	Alumina	9.19
	Lime	0.92
	Magnesia	0.88
	Carbonate of lime	27 09
	Phosphoric acid	Traces
	Silica	9.88
Undecomposed by Hydrochloric acid 42.96 per cent.	Sesquioxide of iron	1.91
	Alumina	10.33
	Magnesia	0.80
	Silica	29.92
		101.02

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.26	5.48	19 52	0.92	1.68	27.09	Traces	39.80

Loss by Ignition
5.27 = 101.02.

Station 301.

Lat. 74° 1′ N., long. 1° 20′ W.; 1684 fathoms (3080 metres); bottom-temperature — 1.6°. Biloculina clay of a darker brown than the foregoing sample, with a little grey clay in the under part; comparatively few Foraminifera.

	Glødningstab	4.83
Dekomponeret af Saltsyre 22.75 pCt.	Jernoxydul	1.28
	Jernoxyd	5.09
	Lerjord	3.88
	Kalk	0.15
	Magnesia	1.56
	Kulsur Kalk	5.68
	Fosforsyre	Spor
	Kiselsyre	5.11
Udekomponeret af Saltsyre 71.61 pCt.	Jernoxyd	2.64
	Lerjord	15.56
	Magnesia	0.70
	Kiselsyre	52.71
	Sum	99.19

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.28	7.73	19.44	0.15	2.26	5.68	Spor	57.82

Glødn.tab	Sum
4.83	99.19

Station 302.

N. B. 75° 16′, V. L. 0° 54′. 1985 Favne (3630 Meter). — 1.7°. En meget liden Prøve af lysbrunt Biloculinler.

	Glødningstab	3.78
Dekomponeret af Saltsyre 19.95 pCt.	Jernoxydul	1.38
	Jernoxyd	2.94
	Lerjord	3.82
	Kalk	0.81
	Magnesia	2.09
	Kulsur Kalk	8.91
	Fosforsyre	Spor
	Kiselsyre	?
Udekomponeret af Saltsyre 76.27 pCt.	Uopl. Residuum + opløsel. Kiselsyre	76.27
	Sum	100.00

Station 306.

N. B. 75° 0′. Ø. L. 10° 27′. 1334 Favne (2440 Meter). — 1.3°. Biloculinlêr, mørkere i Farve end det foregaaende. Forholdsvis faa Foraminiferer; foruden Biloculinler fandtes væsentlig *Lituola* og *Nonionina*.

	Loss by ignition	4.83
Decomposed by Hydrochloric acid 22.75 pCt.	Protoxide of iron	1.28
	Sesquioxide of iron	5.09
	Alumina	3.88
	Lime	0.15
	Magnesia	1.56
	Carbonate of lime	5.68
	Phosphoric acid	Traces
	Silica	5.11
Undecomposed by Hydrochloric acid 71.61 pCt.	Sesquioxide of iron	2.64
	Alumina	15.56
	Magnesia	0.70
	Silica	52.71
		99.19

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.28	7.73	19.44	0.15	2.26	5.68	Traces	57.82

Loss by Ignition
4.83 = 99.19

Station 302.

Lat. 75° 16′ N., long. 0° 54′ W.; 1985 fathoms (3630 metres); bottom-temperature — 1.7°. A very small sample of light-brown Biloculina clay.

	Loss by ignition	3.78
Decomposed by Hydrochloric Acid 19.95 per cent.	Protoxide of iron	1.38
	Sesquioxide of iron	2.94
	Alumina	3.82
	Lime	0.81
	Magnesia	2.09
	Carbonate of lime	8.91
	Phosphoric acid	Traces
	Silica	?
Undecomposed by Hydrochloric Acid 76.27 per cent.	Insoluble residue + soluble Silica	76.27
		100.00

Station 306.

Lat. 75° 0′ N., long. 10° 27′ E.; 1334 fathoms (2440 metres); bottom-temperature — 1.3°. Biloculina clay, darker in colour than the preceding sample, containing comparatively few Foraminifera; the genera most numerously represented next to *Biloculina* were *Lituola* and *Nonionina*.

	Glødningstab	2.48
Dekomponeret af Saltsyre 30.40 pCt.	Jernoxydul	1.19
	Jernoxyd	4.92
	Lerjord	2.46
	Kalk	1.08
	Magnesia	1.80
	Kulsur Kalk	12.20
	Fosforsyre	Spor
	Kiselsyre	6.75
Udekomponeret af Saltsyre 68.00 pCt.	Jernoxyd	2.34
	Lerjord	13.44
	Magnesia	1.50
	Kiselsyre	50.72
	Sum	100.88

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.19	7.26	15.90	1.08	3.30	12.20	Spor	57.47

Glødn.tab	Sum
2.48	100.88

Station 351.

N. B. 77° 49′. V. L. 0° 9′. 1640 Favne (2999 Meter). — 1.5°. Mørkbrunt Biloculinler. Mange Foraminiferer, overveiende Globigeriner. Kun faa af Slægten *Lituola*.

Lerets specifiske Vægt var 2.77.

	Glødningstab	4.56
Dekomponeret af Saltsyre 41.72 pCt.	Jernoxydul	1.25
	Jernoxyd	4.06
	Lerjord	3.28
	Kalk	0.12
	Magnesia	2.05
	Kulsur Kalk	23.66
	Fosforsyre	Spor
	Kiselsyre	7.30
Udekomponeret af Saltsyre 54.20 pCt.	Jernoxyd	2.46
	Lerjord	13.33
	Magnesia	Spor
	Kiselsyre	38.41
	Sum	100.48

Samlede Bestanddele:

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.25	6.52	16.61	0.12	2.02	23.66	Spor	45.71

Glødn.tab	Sum
4.56	100.48

Væsentlig som en Følge af Biloculinlerets vexlende Kalkgehalt viser det sig ved de foregaaende Analyser, at

	Loss by ignition	2.48
Decomposed by Hydrochloric acid 30.40 per cent.	Protoxide of iron	1.19
	Sesquioxide of iron	4.92
	Alumina	2.46
	Lime	1.08
	Magnesia	1.80
	Carbonate of lime	12.20
	Phosphoric acid	Traces
	Silica	6.75
Undecomposed by Hydrochloric acid 68.00 per cent.	Sesquioxide of iron	2.34
	Alumina	13.44
	Magnesia	1.50
	Silica	50.72
		100.88

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.19	7.26	15.90	1.08	3.30	12.20	Traces	57.47

Loss by Ignition.
2.48 = 100.88.

Station 351.

Lat. 77° 49′ N., long. 0° 9′ W.; 1640 fathoms (2999 metres); bottom-temperature — 1.5°. Dark-brown Biloculina clay containing a great many Foraminifera, chiefly *Globigerinæ;* but very few belonging to the genus *Lituola.*

Specific Gravity of Clay 2.77.

	Loss by ignition	4.56
Decomposed by Hydrochloric acid 41.72 per cent.	Protoxide of iron	1.25
	Sesquioxide of iron	4.06
	Alumina	3.28
	Lime	0.12
	Magnesia	2.05
	Carbonate of lime	23.66
	Phosphoric acid	Traces
	Silica	7.30
Undecomposed by Hydrochloric acid 54.20 per cent.	Sesquioxide of iron	2.46
	Alumina	13.33
	Magnesia	Traces
	Silica	38.41
		100.48

Constituents of Sample: —

FeO	Fe_2O_3	Al_2O_3	CaO	MgO	$CaCO_3$	P_2O_5	SiO_2
1.25	6.52	16.61	0.12	2.02	23.66	Traces	45.71

Loss by Ignition.
4.56 = 100.48.

Principally by reason of the variable amount of lime in Biloculina clay, the proportion of deposit decomposed

følgende skal se, fortjener disse Bundprøver ogsaa af andre Grunde Opmærksomhed, da de hører til det mest kalkfattige Parti af Biloculinleret.

Efter hvad der forud er sagt, vil det være indlysende, at Kjendskabet til Biloculinlerets Kalkgehalt frembyder en særegen Interesse baade for det zoologiske og det fysiske Studium af Havets Naturforhold. Foruden de foregaaende fuldstændige Analyser af Biloculinleret har jeg derfor bestemt dets Kalkgehalt i de fleste af de Prøver, der er optagne indenfor dette Sediments Omraade. I den følgende Tabel findes forøvrigt ogsaa nogle Analyser af Prøver fra Overgangsleret.

other respect deserving of attention, consisting as they do of Biloculina clay from the locality in which that deposit is found to contain the smallest amount of lime.

From what has been previously stated, it must obviously be of special importance for the study of the physical and biological conditions of the sea, to determine the proportion of lime present in Biloculina clay; and I have, therefore, exclusive of that given in the foregoing complete analyses, also determined the amount of lime in most of the samples brought up within the limits of the said deposit. For the rest, a few analyses of transition clay will be also found in the subjoined Table.

Station.	Nordlig Bredde. (*N. Lat.*)		Længde fra Greenw. (*Long. f. Greenw.*)			Dybde i engl. Favne. (*Depth in Eng. Fath.*)	$CaCO_3$	Fe_2O_3	FeO	Samlet Fe (*Total Fe.*)	Fe_2O_3 : FeO	Anmærkninger. (*Remarks.*)
37	62°	28′	2°	29′	W.	690	9.09	2.08	0.57	1.90	3.65	Overgangsler. — *Transition Clay.*
40	63	22	5	29	W	1215	28.64	2.94	1.79	3.45	1.64	
51	65	53	7	18	W	1163	52.82	2.74	1.14	2.71	2.40	
52	65	47	3	7	W	1861	45.80	3.65	0.88	3.24	4.15	
53	65	13	0	33	E	1539	28.98	3.97	1.08	3.62	3.52	
54	64	47	4	24	E	601	49.18		1.42			
96	66	8	3	0	E	805	24.18	4.15	1.36	3.97	3.05	
98	65	56	5	21	E	388	26.25	3.73	1.33	3.65	2.80	Overgangsler (med et underliggende Lag af graat Ler). — *Transition Clay on an Under Layer of Grey Clay.*
129	67	40	6	42	E	709	30.14	4.43	0.89	3.79	4.97	
178	69	29	12	26	E	1578	32.45	2.85	1.59	3.24	1.80	
181	69	45	8	43	E	1595	27.63	3.55	1.74	3.83	2.04	
183	69	59	6	15	E	1710	40.52	2.59	1.81	3.22	1.43	
184	70	4	9	50	E	1547	21.77	3.10	1.42	3.27	2.18	
205	70	51	13	3	E	1287	21.00	4.97	1.44	4.60	3.45	
214	70	39	0	0	E	1750	29.93	3.67	1.61	3.82	2.28	
215	70	53	2	0	W	1665	40.88	4.13	1.79	4.28	2.31	Meget tyndt Lag af Biloculinler. — *An exceedingly thin Layer of Biloculina Clay.*
217	71	0	5	9	W	829	9.23	3.12	1.03	2.98	3.03	
231	71	21	9	23	W	1032	6.95	3.70	1.76	3.91	2.10	
240	69	2	11	26	W	1004	54.64	2.71	0.79	2.51	3.43	
241	68	41	10	54	W	1119	56.25	3.12	1.28	3.18	2.44	
242	68	36	8	40	W	1033	37.95	3.60	1.59	3.76	2.27	
243	68	32	6	26	W	1385	31.25					
244	68	28	4	17	W	1951	36.55	3.71	1.47	3.74	2.52	
245	68	21	2	5	W	2005	41.18	3.95	0.92	3.48	4.30	
245	68	21	2	5	W	2005	4.66	5.85	1.55	5.30	3.77	Øverste Lag af Biloculinleret. — *Upper Layer consisting of Biloculina Clay.*
248	67	56	4	11	E	778	33.61					
249	68	12	6	35	E	1063	55.43	2.99	1.34	3.13	2.23	
285	73	6	11	56	E	1024	1.95	4.49	2.06	4.74	2.18	Overgangsler. — *Transition Clay.*
294	71	35	15	11	E	637	4.02	2.63	0.95	2.58	2.77	
295	71	59	11	40	E	1110	27.09	3.57	1.26	3.48	2.83	
296	72	15	8	9	E	1440	34.88	3.69	1.30	3.59	2.84	
297	72	36	5	12	E	1280	8.70	4.37	1.42	4.16	3.08	
298	72	52	1	51	E	1500	5.52	4.48	1.05	3.95	4.26	
299	73	10	2	14	W	1366	9.70	4.65	1.41	4.35	3.30	
301	74	1	1	20	W	1684	5.68	5.09	1.28	4.56	3.98	
302	75	16	0	54	W	1985	8.91	2.94	1.38	3.13	2.13	
303	75	12	3	2	E	1200	10.84	3.56	1.16	3.32	3.07	
306	75	0	10	27	E	1334	12.20	4.92	1.19	4.37	4.13	
308	74	57	12	43	E	1136	22.32					
332	75	56	11	36	E	1149	25.23	3.63	1.62	3.81	2.24	
344	76	42	11	16	E	1017	3.50	4.00	1.91	4.29	2.09	Overgangsler. — *Transition Clay.*
349	76	30	2	57	E	1487	10.23	4.00	1.15	3.70	3.48	
351	77	49	0	9	W	1640	23.66	4.03	1.31	3.85	3.08	
352	77	56	3	29	E	1686	7.57	4.19	1.52	4.12	2.76	
353	77	58	5	10	E	1333	34.23	2.82	0.90	2.67	3.13	

Vulkansk Sand og Sandler.

Øen Jan Mayen er som bekjendt af vulkansk Oprindelse. Den stærke lokale Hævning, der har foraarsaget dens Dannelse, giver sig tydeligst tilkjende paa Nordkysten, hvor det egentlige Hovedkrater — den 6000 Fod høie "Beerenberg" — findes. Her træffer vi et Braadyb af 1000 Favne i en Afstand af omtrent 2 Mile fra Øens nordligste Punkt. Paa Øst- og Vestsiden af Øen skraaner Kysten mindre brat ned mod Dybet. Ved de talrige Dybdemaalinger, som Expeditionen her har foretaget, befandtes alle Bundprøver, der var optagne paa mindre Dyb end 600 Favne, at bestaa af et graasort fint Sand eller Sandler, der indeholdt talrige Brudstykker af den basaltiske Lavas Mineraler: Olivin, Augit, Hornblende. Disse forekom ofte med vel uddannede og vel bevarede Krystalflader.

Det vulkanske Sandler viser sig under Mikroskopet at indeholde en Mængde forskjelligfarvede krystallinske Korn, der væsentlig bestaar af de ovennævnte Mineraler, især er den grønne Olivin meget fremtrædende. Forøvrigt ser man ogsaa en Del sorte metalglindsende Korn, der ved Hjælp af Magneten lader sig udtrække af Bundprøverne. Disse synes i det Hele taget at indeholde de samme Mineraler — i fint fordelt Tilstand — som dem der forekommer i de rige Sandleier langs Jan Mayens Kyster. Dette sorte Sand er dannet af temmelig grove Korn af Lava, Tuf, Olivin, Feldspath, Augit, Hornblende og Magnetjern.

Af det sidstnævnte Mineral fandt jeg i Sandet ved to Bestemmelser 26 pCt. og 29 pCt.[1]

Fra disse Sanddynger, der ligger ubeskyttede for Bølgerne langs Øens aabne Kyster, maa der stadig kunne føres nyt Materiale ud til den nærliggende Havbund.

I Syd for Jan Mayen synes der ifølge tidligere Lodskud at være grundt Vand (100 Favne) indtil en Afstand af omtrent 15 Mile fra Øen.

Her har den norske Expedition imidlertid ikke foretaget nogen Dybdemaaling, og jeg tør derfor ikke indestaa for Rigtigheden af de Grændser, jeg paa Kartet har optrukket for det vulkanske Lers Udbredelse søndenfor Jan Mayen.

I Bundprøverne fra Kysten af denne Ø findes næsten ingen Dyrelevninger, og Leret indeholder kun Spor af kulsur Kalk.

---

[1] Professor Carl Vogt, der i 1863 gjæstede Jan Mayen, har ogsaa underkastet dette Sand en Undersøgelse, ved hvilken han fandt 21.6 pCt. Magnetjern. (Nord-Fahrt entlang der Norwegischen Küste, nach dem Nordcap, den Inseln Jan Mayen und Island, unternommen von Dr. Georg Berna 1863).

Volcanic Sand and Sabulous Clay.

The island of Jan Mayen is, as well known, of volcanic origin. More especially on the north coast, have the prodigous forces whereby the ocean-bed was upheaved in this locality of the North Atlantic, left evidence of their bygone action; there lies Mount Beerenberg, the principal crater — 6000 feet above the level of the sea. About 2 geographical miles from the most northerly extremity of the island we meet with a depth of 1000 fathoms. Off the eastern and western shores, the bottom is found to shelve less rapidly down to the depths. All of the numerous samples collected on the Expedition throughout this tract from depths of less than 600 fathoms, consisted exclusively of a dark-grey sand or sabulous clay, containing fragments of basaltic lava, as olivine, augite, hornblende. Many of these had well developed and well preserved crystal faces.

The volcanic sabulous clay, when examined under the microscope, is found to contain a great many differently coloured crystalline particles, consisting chiefly of the abovementioned minerals, in particular green olivine. For the rest, numerous black granules of metallic lustre are also observed, which, with the aid of a magnet, may be extracted from the clay. They would appear to consist in greater part of the same minerals — in a state of minute subdivision — that occur in the sand forming extensive banks on the coast of Jan Mayen. This black sand is composed of comparatively coarse particles of lava, tuf, olivine, feldspar, augite, hornblende, and magnetite.

The last of these minerals I found, from two determinations, to constitute respectively 26 per cent and 29 per cent of the sand.[1]

These sand-hills, stretching as they do along the exposed shores of the island, must obviously at all times contribute to the distribution of deposit over the adjacent parts of the sea-bed.

South of Jan Mayen — as shown by the results of former soundings — comparatively shallow water (100 fathoms) extends about 15 geographical miles from the coast.

On the Norwegian Expedition, the depth was not measured in this locality, and I cannot therefore answer for the accuracy of the limits I have traced on the map to mark the distribution of the volcanic clay south of the island.

Very few, if any, animal remains are found in samples of the bottom from the coast of Jan Mayen, and the deposit contains traces only of carbonate of lime.

---

[1] Professor Carl Vogt, who visited Jan Mayen in 1863, has also submitted this sand to analysis: he found 21.6 per cent of magnetite. (Nord-Fahrt entlang der Norwegischen Küste, nach dem Nordkap, den Inseln Jan Mayen und Island, unternommen von Dr. Georg Berna 1863.)

indenfor det Feldt, der paa Kartet er afgrændset som graat Ler.

Station	32	417	Favne
—	57	161	—
—	100	194	—
—	101	223	—
—	103	193	—
—	114	120	—
—	115	132	—
—	118	141	—
—	120	190	—
—	123	246	—
—	124	350	—
—	134[1]	878	—
—	137	452	—
—	139	175	—
—	142	178	—
—	143	189	—
—	147	142	—
—	164	457	—
—	174	337	—
—	175	415	—
—	195	107	—
—	237	263	—
—	286	447	—
—	290	191	—
—	316	129	—
—	324	233	—
—	334	403	—
—	335	179	—
—	336	70	—
—	340	58	—
—	342	523	—
—	356	110	—
—	358	93	—
—	368	315	—
—	369	87	—
—	370	109	—

Forbinder man med en Linie de yderste og dybeste af de ovennævnte Stationer vil man kunne betragte denne som Grændsen for Stenenes *almindelige* og *regelmæssige* Forekomst i Havbundens Afleiringer. Denne Linie vil nordenfor den 65de Breddegrad omtrent følge Grændsen for det graa Lers Udbredelse.

At dømme efter de Bundprøver, der er optagne søndenfor den 65de Breddegrad, maa man drage den Slutning, at Norges Kystbanker her er meget fattigere paa Stene end længere nord.

I Bundprøverne fra det brune Ler forekommer Stene kun spredt og enkeltvis. Der er imidlertid i denne Henseende en betydelig Forskjel mellem det nordlige og sydlige Parti af Havet. Medens vi i syd for den 72de Breddegrad kun ganske sjelden træffer Stene i Biloculinleret, er

[1] Se Side 40.

were brought up within the tract marked off on the Map as grey clay.

Station	32	417	fathoms
—	57	161	—
—	100	194	—
—	101	223	—
—	103	193	—
—	114	120	—
—	115	132	—
—	118	141	—
—	120	190	—
—	123	246	—
—	124	350	—
—	134[1]	878	—
—	137	452	—
—	139	175	—
—	142	178	—
—	143	189	—
—	147	142	—
—	164	457	—
—	174	337	—
—	175	414	—
—	195	107	—
—	237	263	—
—	286	447	—
	290	191	—
—	316	129	—
—	324	233	—
—	334	403	—
—	335	179	—
—	336	70	—
—	340	58	—
—	342	523	—
—	356	110	—
—	358	93	—
—	368	315	—
—	369	87	—
—	370	109	—

If we connect by means of a line the deepest and outermost of the above-mentioned Stations, such line may be regarded as the limit of the *common* and *regular* occurrence of the pebbles in the surface-layer of the ocean. The said line will, north of the 65th parallel of latitude, very nearly coincide with the distribution of the grey clay.

To judge from the bottom-samples brought up south of the 65th parallel of latitude, we must draw the inference, that the coastal banks of Norway in this locality have their surface-layer far less abundantly supplied with pebbles than is the case with the banks farther north.

In the samples from the brown clay, the pebbles do not occur otherwise than isolated. In this respect, however, there is a considerable difference between the northern and the southern tracts of the ocean. Thus, whereas we, south of the 72nd parallel of latitude, comparatively seldom meet

[1] See p. 40.

disse derimod temmelig almindelige i Dybet vest for Spidsbergen og Beeren Eiland, hvor Drivisen i særlig Grad er fremherskende. Blandt de Stene, som her blev fundne i Bundprøverne, var smaa Stykker af Lerskifer især deleshed talrige. Disse var ofte, medens de endnu befandt sig i fugtig Tilstand, meget bløde, stundom ikke synderlig haardere end almindeligt fast Ler. Hvorvidt nogen Forandring af Stenene i denne Retning kan begunstiges af Forholdene paa Dybet, er et Spørgsmaal, som muligens fortjener nærmere Overveielse.

Hvad der forøvrigt tiltrækker sig Opmærksomhed, er de temmelig hyppige Fund af Flint- og Kridtstykker, der endog forekommer nordenfor den 78de Breddegrad. Som det vil sees, blev der ogsaa paa et Sted (Stat. 100) fundet et i Kridtformationen hjemmehørende Fossil (Belemnites). Kul fandtes i Østhavet (Stat. 266, 269, 275) og i Havet vest for Spidsbergen (Stat. 340, 349, 351). Det kan have sin Oprindelse fra Beeren Eiland og fra Spidsbergen.

De større Stene, der blev optagne med Skraben eller Travlen er nærmere beskrevne i den foregaaende Fortegnelse over Stationerne. Blandt disse kan særlig fremhæves følgende:

Station 18 (en Marmorblok $0.26 \times 0.15 \times 0.15^m$, et Stykke af en Breccie), 32 (Pimpsten etc.), 40 (Se Side 53), 101 (Flint, Kridt etc.), 124 (Flint, Kridt etc.), 137 (Stene med Skurstriber), 147, 164 (Flint, Kridt, Porfyrmandelsten med Skurstriber, lig Holmestrands eller Tønsbergs), 195, 237 (vulkanske Mineraler og Bergarter), 260, 267, 275, (Stenkul), 286, 290, 353 (en Marmorblok ca. 80 Kgr.)

Slutning.

Jeg har paa de første Sider af denne Afhandling kortelig henpeget paa de Kræfter, der paa Forhaand maa antages at have været medvirkende ved Dannelsen af Bundens Afleiringer i Nordhavet.

Idet jeg henviser til disse Slutninger a priori, vil jeg nu forsøge paa i al Korthed at fremstille Resultaterne af de foreliggende Undersøgelser.

Det graa Ler er udbredt over hele Havbunden fra Kysterne og ned til de største Dybder. Fra 900 a 1100 Favne og videre nedover finder vi imidlertid det graa Ler bedækket af et brunfarvet Sediment (Biloculinler), der foruden ved sin Farve udmærker sig ved sit Indhold af visse Foraminiferer, som ikke forekommer paa de høiere liggende Partier af Havbunden, hvor det graa Ler er ubedækket.

with pebbles in Biloculina clay, they are rather common in the deep water west of Spitzbergen and Beeren Eiland, where drift-ice specially abounds. Among the pebbles found here in the bottom-samples, were small fragments of argillaceous schist, exceedingly numerous. Such fragments were often, whilst still in a moist state, very soft, sometimes but very little harder than common, firm clay. Whether any change in the consistence of the pebbles may be produced in the deep layers of the sea, is a question possibly deserving closer investigation.

A phenomenon that also attracts attention, are the numerous fragments of flint and chalk that occur even north of the 78th parallel of latitude. As we have shown, in one locality (St. 100) was found a fossil (belemnite) belonging to the chalk formation. Coal occurred in the Barent's Sea (Stats. 266, 269, 275), and in the ocean-tract west of Spitzbergen (Stats. 340, 349, 351). Its origin may possibly be traced to Beeren Eiland or Spitzbergen.

The larger stones brought up with the dredge or trawl have been more accurately described in the foregoing List of Stations. Amongst such, the following can in particular be specified: —

Station 18 (a block of marble, measuring $0.25 \times 0.15 \times 0.15$, a fragment of a breccia); Stat. 32 (pumice stone etc.); Stat. 40 (see page 33); Stat. 101 (flint, chalk, etc.); Stat. 124 (flint chalk, etc); Stat. 137 (stones with striæ); Stats. 147, 164 (flint, chalk, amygdaloidal porphyry with striæ, bearing a strong resemblance to that occurring at Holmestrand and Tønsberg); Stats. 195, 237 (volcanic minerals and rocks); Stats. 260, 267, 275 (coal); Stats. 286, 290, 353 (a block of marble, weighing about 80 kilogrammes).

Concluding Remarks.

In the first pages of this Memoir, I have briefly pointed out the concurrent forces that may be assumed to have coöperated in forming the deposits covering the bottom of the North Atlantic.

Referring to these *à priori* conclusions, I will now give a brief *resumé* of the results deduced from the investigations here set forth.

The grey clay is distributed over the whole sea-bottom, from the shallowest coastal tracts down to the greatest depths. At a depth of 900 to 1100 fathoms, and still deeper, this grey clay is, however, covered with a brown sediment (Biloculina clay), distinguished, apart from its colour, by containing certain species of Foraminifera that do not occur in the more elevated parts of the sea-bottom, where the grey clay constitutes the surface-layer.

De Bundprøver, der er optagne paa disse mindre Dybder (fra 1100 à 900 Favne og opover), bestaar altsaa udelukkende af graat Ler. Kalkgehalten i disse Bundprøver er temmelig variabel, men opnaar sjelden nogen betydelig Størrelse (Middel af Bestemmelserne ca. 9 pCt kulsur Kalk).

Paa de større Dybder, hvor altsaa det graa Ler kun forekommer som det underliggende Lag bedækket af Biloculinler, indeholder det næsten ingen Dyrelevninger og derfor kun smaa Mængder af Kalk. Biloculinleret synes overalt at ligge som et bestemt adskilt Lag over det graa Ler og gaar ikke gradvis over i dette. Biloculinlerets Kalkgehalt er stærkt varierende, men en tydelig Lovmæssighed giver sig dog her tilkjende, saaledes som det vil fremgaa af det denne Afhandling ledsagende Kart. Da kun et mindre Parti af Biloculinleret indeholder mere end 40 pCt. kulsur Kalk og da alle Observationer stadfæster, at dette Sediment kun danner et tyndt Lag paa Havbunden, kan dette for Nordhavet karakteristiske Dybvandssediment med Hensyn til Kalkrigdom i det store og hele taget ikke sammenlignes med det af de engelske Expeditioner fundne og beskrevne „Globigerina ooze", der ifølge Prof. Braziers Analyser[1] hovedsagelig bestaar af kulsur Kalk. I Særdeleshed bliver denne Forskjel fremtrædende, naar vi ser hen til det mest kalkfattige Parti af Biloculinleret. Denne Fattigdom paa kulsur Kalk og paa uorganiske Dyrelevninger i det hele taget fører til den ikke uventede Slutning, at Nordhavet med Hensyn til Dyrelivets kvantitative Udvikling staar langt tilbage for de sydligere, varmere Have.

De organiske Kræfter har altsaa i det hele taget kun spillet en underordnet Rolle ved Dannelsen af Nordhavets Afleiringer. Disse synes forøvrigt ogsaa kun at indeholde lidet af saadanne Mineraler, der tilføres Havbunden ved Vulkanernes Udbrud.

De vigtigste Bidrag til disse Sedimenters Dannelse maa vistnok skrive sig fra det Materiale, der gjennem Isen og Bræelvene føres ud i Havet. Hvorledes Nordhavet paa Grund af sine Omgivelser er særlig gunstig stillet for en saadan Tilførsel har jeg paapeget i den første Del af denne Afhandling. Fra Island, Grønland og Spidsbergen, hvor de glaciale Kræfter er saa stærkt fremtrædende, maa der nødvendigvis gjennem de slamrige Bræelve[2] forflyttes store Masser af Landjordens faste Materiale ud i Havet (i det førstnævnte Land understøttes Isens Ødelæggelsesværk ogsaa af den vulkanske Virksomhed). Vi har Grund til at formode, at dette udskyllede Slam vil kunne sprede sig over hele Nordhavets — forholdsvis indskrænkede — Areal førend det fuldstændig bundfældes.[3]

[1] "The Atlantic" Vol. II Appendix A.

[2] Med Hensyn til de islandske og grønlandske Bræelves Virksomhed henviser jeg til Hr. Stipendiat Amund Hellands Afhandling „Om Islands Jøkler" og Hr. I. A. D. Jensens „Beretning om en Undersøgelse af Grønlands Vestkyst", trykt i „Meddelelser om Grønland." Kjøbenhavn 1881.

[3] Ifølge en Meddelelse af Prof. Jonstrup skal man kunne opbevare Vandprøver fra de Grønlandske Bræelve i maanedsvis, førend de svævende mineralske Partikler fuldkommen bundfældes.

The samples of the bottom brought up from such lesser depths (from 900 à 1100 fathoms and shallower localities) consist therefore exclusively of grey clay. The amount of lime in these samples varies not a little, but is rarely considerable (mean determination about 9 per cent of carbonate of lime).

In the great depths, where the grey clay occurs accordingly as the under-layer, the surface-layer consisting of Biloculina clay, it contains scarcely any organic remains, and therefore but a small percentage of lime. The Biloculina clay would appear to extend almost everywhere as a well-defined separate layer above the grey clay, and not to pass into it gradually. The percentage of lime occurring in Biloculina clay varies exceedingly, but follows a manifest law, as appears from the chart accompanying this Memoir. A small portion only of the Biloculina clay containing more than 40 per cent of carbonate of lime, and the observations all confirming the fact, that this sediment constitutes but a thin layer, the said deep-water layer occurring on the bottom of the North Ocean cannot, as regards its amount of lime, be compared with that found on the British Expeditions, and termed "Globigerina ooze," which, according to Professor Brazier's analyses,[1] is found to consist chiefly of carbonate of lime. And this distinction is specially obvious if we regard such layers of Biloculina clay as contain the least amount of lime. This small percentage of carbonate of lime and of inorganic animal remains, leads to the warrantable inference, that the North Ocean, with regard to the quantitative development of animal life, cannot compare with the warm southern seas.

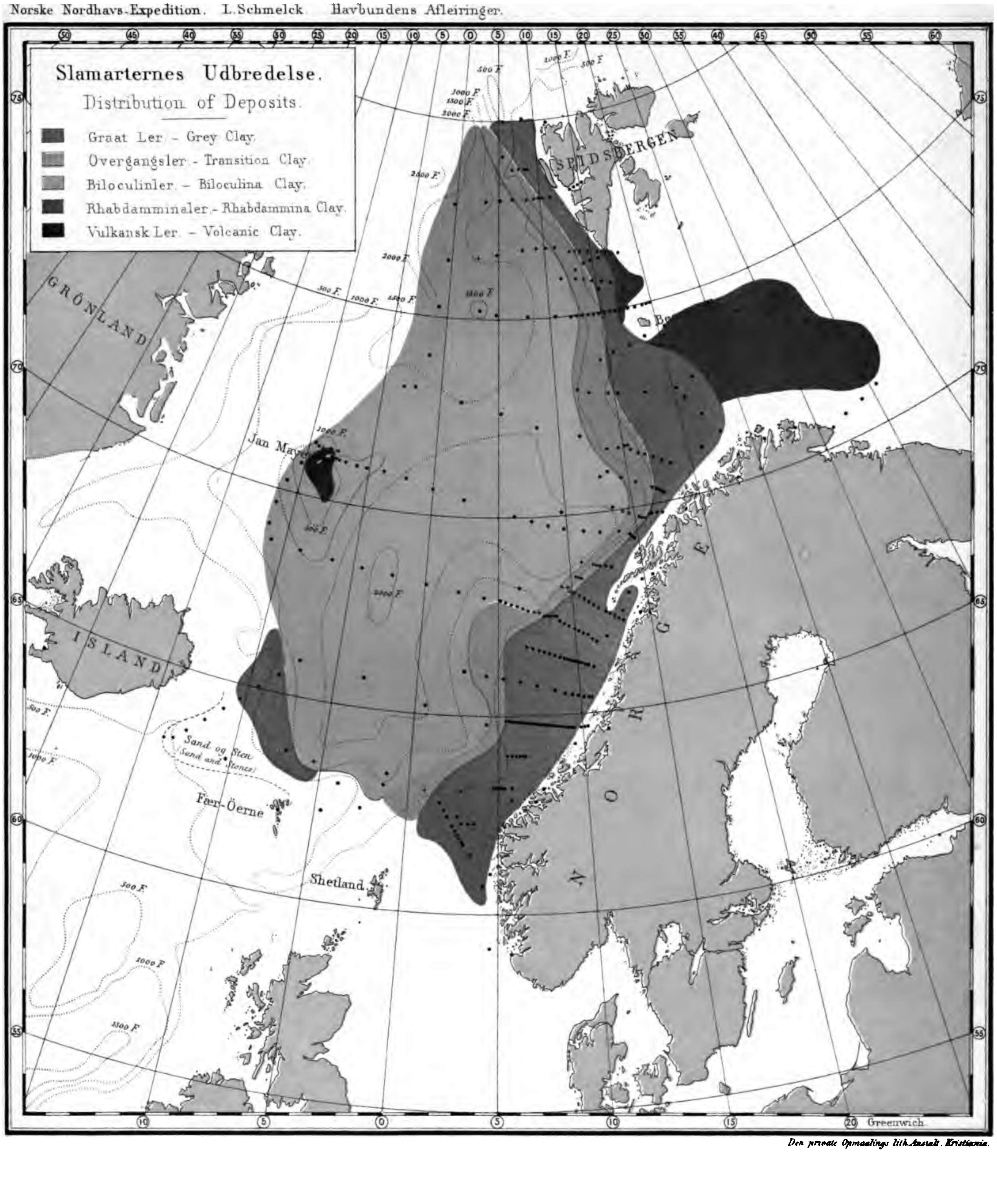
Hence, organic agency must, on the whole, be regarded as merely subordinate in the formation of the surface-layers of the North Ocean. Moreover, these layers would appear to contain but a small proportion of the mineral substances spread over the sea-bottom by volcanic eruptions.

The chief portion of these sedimentary formations must apparently consist of the solid matter carried out to sea by drift-ice and glacier rivers. That the North Atlantic, in this respect, by reason of its surroundings, must be favourably situated, has been pointed out in the first part of this Memoir. From Iceland, Greenland, and Spitzbergen, where glacial agency is so prominent, large masses of solid matter detached from the land must, by the glacier torrents,[2] specially rich as they are in ooze, be borne out to sea (in Iceland the destructive action of the ice is augmented by volcanic agency). There is reason to assume, that this ooze must spread over the whole bottom of the North Atlantic — comparatively limited as it is in area — before being thoroughly precipitated.[3]

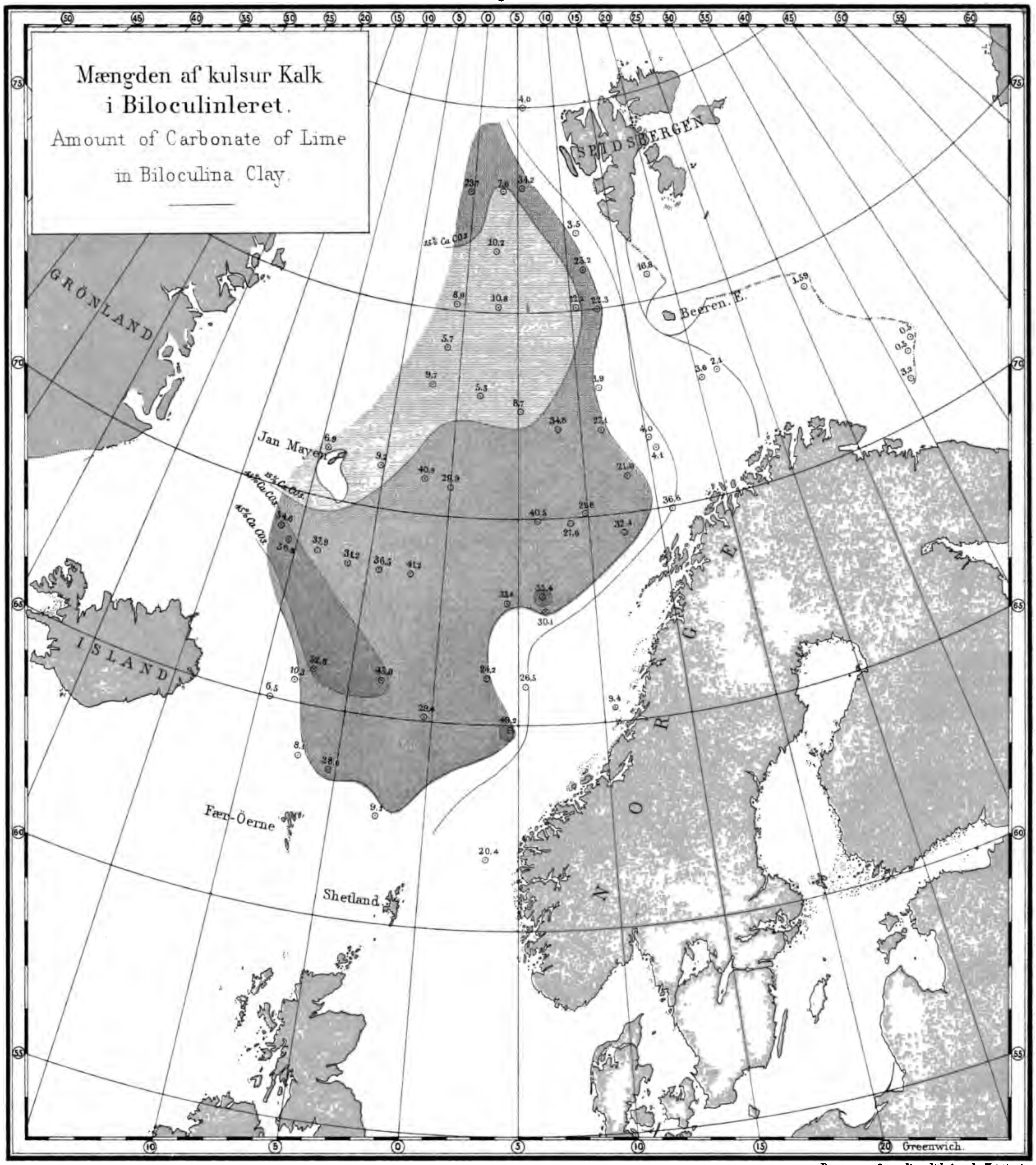
[1] "The Atlantic." Vol. II Appendix A.

[2] In regard to the Icelandic and Greenland torrents, the reader is referred to Mr. Amund Helland's Memoir "Om Islands Jøkler;" and to Mr. I. A. D. Jensen's "Beretning om en Undersøgelse af Grønlands Vestkyst," published in "Meddelelser om Grønland," Kjøbenhavn 1881.

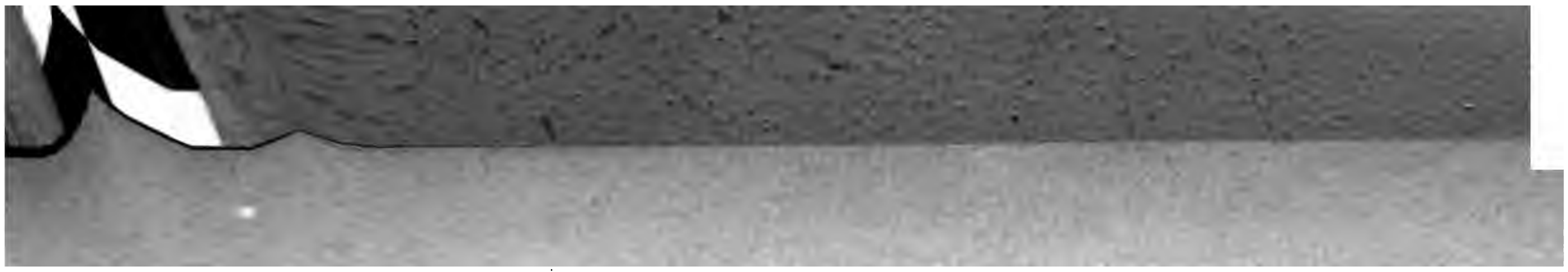
[3] According to a communication from Professor Jonstrup, samples of water from the Greenland glacier torrents, can be kept for months before the suspended mineral particles are thoroughly precipitated.



Den private Opmaalings lith. Anstalt. Kristiania.



Den private Opmaalings lith. Anstalt, Kristiania.



THE NORWEGIAN NORTH-ATLANTIC EXPEDITION
1876—1878.

IX.

CHEMISTRY.

I. ON THE SOLID MATTER IN SEA-WATER.
II. ON OCEANIC DEPOSITS.

BY

LUDVIG SCHMELCK.

WITH 1 WOODCUT AND 2 MAPS.

CHRISTIANIA.
PRINTED BY GRØNDAHL & SØN.
1882.

LEIPZIG, K. F. KÖHLER.
LONDON, SAMPSON, LOW, MARSTON, SEARLE & RIVINGTON.
PARIS, K. NILSON.

551.461 .N863 f
General reports.
Stanford University Libraries
3 6105 031 181 261

Branner Li
551.4
N863
f
v. 1: